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## Electrochemical Industry

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## CONTENTS.

Editorial .....	43
The Efficiency of Electric Furnaces. By J. W. Richards .....	45
Cathodic Reduction. By A. T. Weightman .....	46
Storage Battery Invention. By Hugh Rodman .....	47
Electrolytic Dissolution of Soluble Anodes. By W. McA. Johnson .....	48
The Theory of the Electrolytic Rectifier. By K. E. Guthe .....	48
The Electrochemical Industries of Niagara Falls, II. By J. W. Richards .....	49
Pioneers of Electrochemistry: A. H. Cowles .....	56
Niagara Falls Meeting of the American Electrochemical Society .....	57
Pumps and other Mechanical Accessories in Electrochemical Plants. By D. H. Browne .....	62
Electrochemical Lectures .....	62
Analysis of Current Electrochemical Patents. By G. P. Scholl .....	63
The Conductivity and Freezing Points of Aqueous Solutions of Certain Metallic Salts of Tartaric, Malic and Succinic Acids. By O. F. Tower .....	67
Testing Carbon Electrodes. By F. A. J. Fitzgerald .....	68
Synopsis of Articles in other Journals. By Carl Hering .....	69
Current Notes .....	74
Correspondence: The Electromotive Force of the Daniell Cell. By J. W. Richards .....	75
Book Reviews .....	75
Books Received .....	76
Closed Continuous-Working Electric Furnace .....	76
A New Storage Battery .....	77
Personal .....	77
Obituary .....	78
Industrial Notes .....	78
Digest of U. S. Patents Prior to July, 1902. (Alkali Processes with Mercury Cathodes.) By Byrnes & Townsend .....	78

## THE NIAGARA FALLS MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY.

The Niagara Falls meeting of the American Electrochemical Society, a full report of which is given in this issue, has proved the splendid success which had been hoped for. All who attended it will long remember it with pleasure, and we may hope that the success of this meeting will prove stimulating not only to the young society, which may well be proud of its work, but also to the great industry which the Society represents.

Swiftly advancing, indeed, like the electrochemical industry, has been the career of the American Electrochemical Society in the first half year of its life. Founded in Philadelphia on April 3, 1902, it is just six months old; it has now more than 400 members, and has held two general meetings, both of which were extremely well attended; at these meetings there were read and discussed together about 40 papers on various important and interesting subjects. There were well-meaning scientists and engineers who first opposed the foundation of this new society as being superfluous and detrimental to the interests of the older sister societies—the American Institute of Electrical Engineers and the American Chemical Society—and it is a splendid proof of the value of the young society's work that its strongest former opponents now join it and confess that the new society fills a need.

The American Electrochemical Society has certainly secured members from both the other societies, without being detrimental to their interests in any way—on the contrary, while the watchword of the new society is naturally differentiation and specialization on the distinct limited field of electrochemistry, it has broadened the mind of both electrical engineers and chemists; it has brought them together, and it is, indeed, now the connecting link between the American Institute of Electrical Engineers and the American Chemical Society. By attracting the best members of these two societies and bringing them into personal contact with each other, it stimulates original thought on new lines; surely, the electrical engineer can always learn something from the chemist, and vice versa. But besides this, the American Electrochemical Society has brought together the electrochemical specialists of industry and science, and the exchange of opinion between both classes of electrochemical workers has already proven to be of considerable value to both.

The quality of the papers read at the two meetings has been unexpectedly high. Electrical engineers, chemists and physicists of established reputation have contributed papers; and with them there are the young, energetic electrochemical workers pushing to the front. Youth is, indeed, the keynote of the success of the new society. It is only natural that in such a young industry and science there is no uniformity of opinion; there are no standardized methods, and there is no

orthodox faith. It would be an unfavorable symptom if it was different. Just for that reason, it is of the highest importance that there should be animated discussion, there should be freedom of speech—even if sometimes a speaker hurts the scientific feelings of others, by attacking their pet theories. The American Electrochemical Society is no mutual-admiration society; it is a society to exchange views, to disseminate among the members all the information known, and to stimulate new thought and new work. In regard to the discussion of the papers, there is room for improvement; the value of the discussion would be considerably enhanced if the papers were printed and distributed in advance of the meeting, so that it would be possible for the members to study them carefully and prepare what they have to say in the discussion. We understand such a plan has already been taken into consideration by the board of directors of the Society, and we trust it will be carried into effect. Surely the money spent for this purpose will be well spent.

Lack of space does not permit here a detailed analysis of the papers read at Niagara; longer abstracts of all of them will be found on the following pages. It may suffice to say here that at both meetings, at Philadelphia and at Niagara Falls, the programme contained papers on subjects of the greatest variety; indeed, in looking over the titles, one is astonished to find how large the field of electrochemistry really is. While professors and scientific workers are slightly in the majority, it is extremely gratifying to see that the practical electrochemical engineers also have contributed their share, and have not hesitated to describe their processes and to tell of their troubles.

Before the Society was founded, the opinion was repeatedly expressed that the secretive methods of the electrochemical manufacturer would be the stumbling block; that the practical engineer might become a member, but would never read a paper. It affords great satisfaction to state that this fear was unfounded. An unexpectedly large number of papers have been read at the two meetings by industrial electrochemists; all of these papers proved to be of great interest, and will form a very valuable part of the transactions of the Society. It is gratifying to see that the practical engineers themselves recognize that a frank statement of what they are doing can never hurt them. Publicity always has been and will be a spur to progress. In this connection we may mention here the names of those electrochemical companies which courteously opened the doors of their workshops to the members and guests of the Society. They were: The International Acheson Graphite Co., the Carborundum Co., the Electrical Lead Reduction Co., and the Atmospheric Products Co.

It is also gratifying to see that the subjects of the papers read and discussed at the meetings were not limited to electrochemistry in the narrowest sense, but repeatedly dealt with problems of physical chemistry. Indeed, an electrochemical problem is often only a special case of a more general problem of physical chemistry. This is why the pioneer society in the field of electrochemistry, the old German Electrochemical Society, has recently changed the name into German Bunsen Society for Applied Physical Chemistry. Nobody would probably recommend an analogous name for the American

Electrochemical Society. But the policy is to be recommended, not to exclude the discussion of problems of physical chemistry. For the electrochemist needs knowledge of the principles of physical chemistry, and it is the duty of a society devoted to the interests of electrochemistry to acquaint its members with the great problems of physical chemistry in general, which may have an important influence on the developments of industrial electrochemistry in the future.

Finally, we may say that a good deal of the success of the new Society has naturally been due to the personal and social element, and to the free intercourse between the members. It is perhaps not accidental that the Society was formed in Philadelphia. The old Quaker city is often called the city of the homes. Electrochemists in Philadelphia first felt that, as electrochemists, they had no home; that, as electrochemists, they were not at home in any of the old large national societies. And when they appealed to the electrochemical engineers and scientists of the country, the hearty and enthusiastic response from all sides disclosed the fact that this was a general feeling all around. The electrochemical engineers and scientists, representing a rapidly-progressing industry and science in the strength of its youth, wanted to have a society for themselves. Thus the American Electrochemical Society was founded. While the social intercourse at the Philadelphia meeting was very pleasant, and many workers in the electrochemical field came there for the first time into close contact with each other, the Niagara Falls meeting was a still greater success in this respect. At Niagara Falls all electrochemists naturally felt that they were at home, and much credit is due to the untiring efforts of the local entertainment committee. On the walks to the Falls, on the visits to the plants, on the trolley trip and the banquet many new acquaintances were formed; and no young electrochemist, who is proud to be an electrochemist, will ever forget the days when he could shake hands with such pioneers as Mr. Acheson, Mr. Bradley, Mr. Cowles and Mr. Hall. There was good will and good feeling all around, and we trust that it may always be so in the American Electrochemical Society.

#### AMERICAN VERSUS GERMAN PRACTICE.

A certain conversation between two members of the American Electrochemical Society at the recent meeting at Niagara Falls was such a good illustration of one of the characteristic differences between American and German practice, that it seems worth while to call attention to it here, especially as we Americans are sometimes criticised rather severely by our foreign colleagues for doing things in a crude way.

While inspecting one of the interesting electrochemical processes, a member of German descent remarked, with great pride, that a certain German company, which had done this same thing fifteen years ago, had obtained a far greater percentage yield of the desired product; to which an American member replied, "and that is no doubt the very reason why the German company failed to make it a success, while the American inventor succeeded." With characteristic German thoroughness, the thing which seems to have been most prominent in the mind of the German experimenter was to get the greatest

possible percentage yield, and after he got the most he could he found that the process was too expensive. The American, however, attacked the problem in a more practical way; what he tried to get was at what percentage yield is the total cost of the desired ultimate product the least. This is certainly the proper way to consider a commercial proposition. In doing this he found that at a very poor yield the final product became quite cheap, while the German had blindly passed by this successful point in his efforts to get as near the theoretical perfection as possible.

As success is what most of us are, or should be, striving for, it seems to be more creditable to succeed in making practical and useful a theoretically-imperfect process, than to make it so perfect theoretically that it becomes useless, and a practical failure. The Germans may answer to this that it depends upon whether one is working for "glory" or for "money;" but is there not also "glory" in succeeding to develop something that is useful to the world at large? Is it not sometimes even greater than the credit of having developed a useless process to high theoretical perfection? We have great respect for the thorough, indefatigable work of the Germans, but we think that they are too apt to fail to appreciate that it also involves ability, patience and hard work to reduce things to practice.

Suppose the development of the electric light had been abandoned in its early days on the ground that it was theoretically extremely imperfect, having a light efficiency of only a few per cent.; we would, then, be still limited to gas and oil, as we were twenty-five years ago. There are other occasions like this in which wastefulness is economy.

Concerning the process above mentioned, it was very interesting and instructive to notice that in the experimental researches to determine the best values of each of a number of factors in the process, one of the co-ordinates in the curves of results was always the cost per pound of the ultimate product, or some similar factor. This, we think, is an eminently practical and the safest and most direct way of finding the best working conditions, and one which might well be followed by others who are searching for the lowest cost of production.

#### ELECTROLYTIC PRODUCTION OF SODA WITH MERCURY CATHODES.

In the present issue we complete the presentation by abstract of the patented forms of electrolytic cells operating through the intermediary of a cathode of mercury to convert solutions of brine into caustic soda. Commercial success here, as always, has been a beacon which has attracted hosts of inventors, and here, as always, there is no single expression for the character of the inventions. The Patent Office is an indiscriminate collector, making no distinctions along the lines of relative value, but insisting only that there shall be no duplicates in its cabinet.

Through the wide diversity of forms there runs, however, a clear and almost vital distinction, the character and aspect of which seems to be little understood, even among workers in the field. This distinction hinges upon the quantity of energy represented by the decomposition, which is dependent upon

whether or not the chemical energy of the oxidation of the sodium is transformed into electrical energy and turned into the electrolyzing circuit. If the oxidation of the alkali metal be effected by means of a "combining circuit"—in other words, if the mercury acts in whole or in part as a bipolar electrode between independent anodes and cathodes—the energy of this transformation is more or less conserved. If, on the other hand, dependence is placed on local action or area of contact for insuring a rapid denudation of the amalgam, the voltage theoretically required for the decomposition is considerably increased. If the surface at which the oxidation of the sodium occurs is not an active electrode face, it becomes immaterial, electrically, what separation, in space or time, may exist between the act of forming the amalgam and its decomposition by water.

#### THE ST. LOUIS WORLD'S FAIR OF 1904.

The Electrical Department of the St. Louis World's Fair has a very energetic director in Professor Goldsborough. At the Niagara meeting of the American Electrochemical Society he made a strong appeal to the electrochemical manufacturers, and, we hope, it will have the desired effect. It is high time to show before the country and before the world the advances of American electrochemical industries. It is sometimes astonishing to find how little the general public knows of electrochemistry and electrometallurgy. Everybody knows aluminum, but very few know how it is made; in fact, the general public is absolutely ignorant of the nature of electrochemical processes. These conditions should certainly be changed in view of the fact that the value of the output of the electrochemical industries in the United States is at present estimated at about \$100,000,000 per year.

The general public cannot be blamed for its ignorance. People have never had an opportunity to see electrochemical processes in operation; of course, they all know and use products of electrochemical industries, but while seeing and using the finished product, they do not know anything about the method by which it is made. Even the finest display of finished products of electrochemical and electrometallurgical industries would not teach the general public anything concerning the methods and possibilities of electrochemistry. To interest people in electrochemistry, it is necessary to show them by an object lesson how electrochemical processes are being worked. Director Goldsborough hits the point in urging manufacturers to exhibit model plants and to show processes in operation.

Director Goldsborough also meets at once a difficulty which seems to be in the way of the fulfillment of his plans. It is a fact that electrochemical manufacturers generally do not want to say or show anything about their methods. Professor Goldsborough points out correctly that manufacturers are not expected to show their trade secrets before the public. What they are urged to show are the general principles of their processes in operation—even if the details of working in the model plant exhibited differ greatly from the methods employed in the industrial plant. If the general public can thus be educated in the general nature and the unlimited possibilities of electrochemical and electrometallurgical processes, an advance of industrial electrochemistry is bound to follow, in comparison with which the progress made in the last ten years may appear slow.



### THE EFFICIENCY OF ELECTRIC FURNACES.

In the following we give an abstract of the recent American Electrochemical Society paper by Dr. J. W. Richards on this subject:

An electric furnace is a furnace for accomplishing a physical or chemical change in materials by means of the agency of heat, said heat being supplied by the transformation of electrical energy. The cases where electrolysis take place in fused electrolytes, are left out of consideration, because they are essentially electrolytic processes in which the heating of the current is unavoidable and incidental to the main process of electrolysis and must be excluded from the term "electric furnace processes," if that term is to retain its individuality and stand for a definite class of operations. If this limitation is understood, the output of an electric furnace is more or less proportional to the amount of heat energy developed in the furnace. It is necessary to say "*more or less proportional*," because, although the amount of heat necessary to produce the change in a given amount of material may be a perfectly definite quantity, yet the proportion of the heat developed in the furnace which is actually absorbed or applied in producing this change is a variable one, being always less than 100 per cent., and frequently very much less. The proportion of the heat energy of the electric current thus applied to producing the useful change in the charge is called the *efficiency* of the furnace.

The usefully applied heat will include one or both of two factors. The first is the amount of heat necessary to heat the charge up to the temperature of the furnace. The second is the heat absorbed in chemical reactions between the constituents of the charge when they are heated to the reacting point. This second part of heat can be calculated from thermochemical data, while the former part of heat—that required for the purely physical changes—can be calculated from the mass of the charge, the specific heats in the solid and liquid states, the latent heat of fusion and the temperature of the furnace.

The efficiency of an electric furnace operation depends on many factors, among which are the following: size of furnace, temperature of reaction, protection from radiation, management of the terminals, feeding and tapping, general management. Of these the most important, in commercial practice, is the size of the furnace. The volume or contents of a furnace increase approximately as the cube of the linear dimensions, while the radiating surface which conditions the loss of heat, increases as the square of the linear dimensions; therefore the proportion of radiating surface to unit of contents *decreases* approximately in proportion as the linear dimensions are increased. It is probable that if a 100 horse-power electric furnace works at an efficiency of 50 per cent., with the other 50 per cent. lost by radiation and conduction, then an 800 horse-power furnace of the same design, working the same process at the same temperature, should give an efficiency nearer to 75 per cent. Most of the desiderata of commercial success of electric furnace work lie in the direction of increasing the size of the furnaces to the furthest limit set by mechanical or physical considerations.

While electric furnaces are generally classified into the resistance type and the arc type, it is better for the present purpose of calculating the efficiency to use a different classification. All furnaces are divided into two large classes. The first class includes these furnaces in which the charge is simply heated without any *chemical* change taking place; the second class includes those in which besides the heating of the charge there is also a chemical change. Each class may be again subdivided into two subclasses, according to whether the heating takes place with or without a melting or fusion of the charge.

*Heating without Fusion and without Chemical Change.*—An example of this is the conversion of anthracite coal into graphite in the Acheson furnace. It is true that some chemical changes probably occur during the conversion, such as the

progressive formation and decomposition of carbides, but these are negligible because their plus and minus heat quantities neutralize each other; the change from amorphous carbon to graphite is a heat *evolving* reaction and therefore must be reckoned as really *assisting* the current or, practically, diminishing in our figuring the calculated efficiency. The data are as follows: 1,000 horse-power, in twenty hours, convert 12,000 pounds of anthracite into 10,000 pounds of graphite. The heat gained in conversion into graphite is about 10 per cent. of the heat supplied by the current; hence the real amount of heat is 110 per cent. of the heating power of the current; of this 82.5 per cent. are utilized, giving an efficiency of  $82.5 \div 110 = 75$  per cent. In the Acheson process of graphitizing electrodes by placing them crosswise, embedded in a resistant material, 1,000 horse-power graphitize 7,000 pounds of electrodes, embedded in 7,000 pounds of granular carbon and lining; the net efficiency of the operation is 38 per cent.

*Heating with Fusion, but without Chemical Change.*—The Jacobs process of fusing calcined bauxite is an illustration. The process is simple fusion by the arc, in a cylindrical pot. With a charge of 3,000 pounds the efficiency is 74 per cent.

*Heating without Fusion, but with a Chemical Change.*—The manufacture of carborundum is a good example. A mixture of carbon, silica sand and salt is heated by the incandescence of a conducting carbon core, until the salt is volatilized carrying off most of the metallic impurities as chlorides, the silica is reduced and combines with the excess of carbon present to form silicon carbide. The furnace is 20 feet long, and 1,000 horse-power is passed through for thirty-six hours. The calculation of the efficiency gives 76.5 per cent.

*Heating with Fusion and with a Chemical Change.*—An example is the production of calcium carbide, for which the calculation gives a net efficiency of 62 per cent. There is, however, a distinct experimental gap in the lack of knowledge of the specific heat of such products of the electric furnace, at high temperatures. When these are known, calculations of the efficiency can be made with much greater exactness.

The net result seems to point to a commercial efficiency of 60 to 75 per cent., calculating with furnaces of 200 to 1,000 horse-power. It seems that furnace operations which involve a heating effect only, without any chemical change, give a higher efficiency in general than those in which a chemical change is also involved. The value of such approximate figures is that any one starting an electric furnace operation should be able to calculate the approximate output to be expected, or, if planning or designing for a given output, will have a guide to indicate the approximate size and capacity of the furnaces needed.

### CATHODIC REDUCTION.

In his American Electrochemical Society paper on this subject, ALFRED T. WEIGHTMAN, of the Electrical Lead Reduction Co. of Niagara Falls, brought out several points which are interesting from a theoretical point of view, and at the same time of practical importance for the electrochemical engineer.

The result of the electrochemical action at a cathode is always reduction—either of ions in the solution, or of the electrode itself. In the first case, that of the reduction of ions, the problem becomes complicated if there are several kinds of cations in the solution which can be reduced; i. e., if we have a mixture of several electrolytes, for instance  $\text{ZnCl}_2$  and  $\text{CuCl}_2$ . Both the Zn and Cu ions are active in transporting the current through the solution; but this does not mean that both must be reduced or deposited upon the cathode. The principal factor which determines the kind of ion to be deposited is, of course, the heat of formation of the different possible reactions: that reaction which absorbs the least energy occurs, in general, most readily; but this statement is only approximately true. The concentration of the two electrolytes and the current density must also be taken into account.



In the second case, that of the reduction of the cathode itself, the cathode is usually a compound of a metal, and the cations (usually H ions) combine with the non-metallic radicle forming a new compound. The best known example is the reduction of the negative plate of a storage cell during charge, from lead sulphate to metallic lead. In this case the cathode consists partly of sulphate and partly of metallic lead (the grid or active material which has already been reduced); hence the two following reactions are theoretically possible: first, the evolution of hydrogen at the metallic lead; second, the reduction of sulphate to lead. From the thermochemical data it appears that the reduction of the sulphate requires a slightly higher voltage than the liberation of hydrogen. It is, therefore, astonishing that not more hydrogen is evolved from a negative plate during charge than is actually found to be the case.

In the Salom process of the electrolytic reduction of galena to metallic lead the reactions are similar. PbS is reduced to Pb, and H<sub>2</sub>S is formed. But on considering the heat of formation of the two possible reactions (evolution of hydrogen or reduction of galena), they are found to lie even farther apart than in the case of the reduction of lead sulphate in the storage battery. The author has made a very large number of experiments with a view to producing as small an evolution of hydrogen as possible, or, in other words, raising the current efficiency as high as possible, so as to reduce the largest quantity of galena for a given current. The author has found that the efficiency is extremely sensitive to the degree of purity of the ore and the nature of these impurities; to the conductivity of the ore; to the fineness of grinding; to the strength and purity of the electrolyte; to the thickness of the layers of ore; to the temperature of the solution, and various other causes—but strange to say, it is almost unaffected by the current density used. The author exhibited several curves and tables, showing the results obtained with various current densities; the similarity in the shape of the curves under different current densities is remarkable; in fact, the numbers of amp. hours required for a given percentage of sponge in the ore agree within the limits of experimental error.

As noticed above, the reaction  $\text{PbS} + \text{H}_2 = \text{Pb} + \text{H}_2\text{S}$  requires a very much higher absorption of energy than the mere liberation of hydrogen; and yet, under proper conditions, the former reaction, which is the one that is wanted, can be kept up to an efficiency yield of 80 per cent., or over, for two-thirds of the reduction, even when the galena is present to the extent of only 25 per cent. On the other hand, it is all the more disappointing that the reaction cannot be brought to a completion, as the last 5 per cent. of PbS cannot be reduced. This, of course, necessitates further treatment to obtain a pure product.

The author has also made experiments concerning the reduction of other sulphides. He used Cu<sub>2</sub>S and NiS; the results obtained are quite different from those for PbS.

For the explanation of the phenomena, the author refers to Caspari's theory of the overvoltage (Ueberspannung). According to this there is a certain overvoltage required to evolve hydrogen, and this overvoltage is different for different materials of the cathode. This overvoltage may account for the results, unexpected from the thermochemical data.

#### STORAGE-BATTERY INVENTION.

In an American Electrochemical Society paper on this subject, HUGH RODMAN discussed the prospects of the Edison battery in comparison with the lead cell.

The author first discussed some general requirements which must be fulfilled in a commercial battery, and which greatly limit the number of possible combinations. A commercial cell must be able to stand an overcharge; and when it is being overcharged, there should be unchanging electrodes in an unchanging electrolyte; the author shows that this requirement reduces the list of available anodes and electrolytes to

lead in sulphuric acid and nickel in alkali hydroxide. This does not mean, however, that the active material must necessarily contain nickel or lead, but simply that the grid must be one or the other of these metals in its appropriate solution. If permanency only is considered, the active material of the "oxygen plate" may be any insoluble oxide or salt; while the grid and active material of the "hydrogen plate," putting aside as impracticable any dissolving material such as zinc, may be either of the same metal as the oxygen plate, as lead in sulphuric acid, or else of some other metal soluble only at the end of a complete reversal of current, as iron in hydroxides. Practically, the whole problem is thus reduced to two classes: first, lead peroxide and spongy lead upon lead plates in sulphuric acid, *i. e.*, the common lead cell; second, mercuric or nickel peroxide upon nickel plates, together with cadmium, nickel or iron sponge upon iron or nickel plates in an alkali hydroxide, *i. e.*, the Edison battery. As the most promising example of the latter type he considers the Edison nickel iron cell and compares it with the ordinary lead cell, concerning the grid, the active material, the electrolyte, and in general.

Concerning the grid the author remarks that the alkali battery has the great advantage of having its support plates of a stiff, easily-worked metal.

Concerning the active material he points out that lead peroxide is a conductor, while nickel peroxide is not, and so must be held in close contact with some conductor itself inactive, as nickel or carbon. Edison packs the active material with powdered or flake graphite, held rigidly in a perforated box. An objection to this is that the dense active mass impedes diffusion. An advantage is that the close-held mass, with its stiff, finely-perforated cover, is apparently not subject to deterioration.

Concerning the electrolyte there is a great difference between the two types of cells. In the acid battery a mass of electrolyte is required, large enough to hold both the acid needed for the reactions and enough over to insure low electrolytic resistance at the end of the discharge; in the alkali battery only enough electrolyte is required to make a bath for the current. While this is one of the most important factors in making the alkali cell light, it adds greatly to an already serious trouble: refilling. Here the alkali cell is inferior to the lead cell. First, the overcharge is greater, on account of the more difficult diffusion. Second, the current is greater for the same energy output. Third, the alkali cell has comparatively a small mass of electrolyte to draw upon. The author thinks that in all, the question of the mass of electrolyte comes to this: that "in the alkali battery we multiply a serious trouble by a factor of three or four, and then halve the means of getting around it." Another trouble arising from refilling is the quality of water used in practice. If the hydrant is the source of supply, it may be the means of putting into the electrolyte some active agent that eventually disintegrates the plates. Again, the acid electrolyte is commercially the better for the ease of handling. Finally, the author thinks, that a battery with unchanging electrodes and changing electrolyte would, in many ways, be better than its opposite; for instance, the change of electrolyte density is, in the lead cell, a very useful means of determining the state of charge and discharge.

Concerning the uses of the storage battery, the author believes that for central station work, which at present takes about 75 per cent. of the battery output, the position of the lead cell seems secure, while for lighter service, particularly for automobiles, where watt efficiency and cost are to some extent subordinate to convenience, the choice will depend largely upon capacity and reliability. Exact data on the alkali cell are wanting and must be wanting until the cells are put into ordinary service with ordinary care and attention; it seems certain that the necessity for frequent refilling will mean trouble and irregularity of working, while the problem of handling the alkali electrolyte and excessive gasing will need most careful consideration.

The author states that the commercial life of lead plates in truck or cab service is about 15,000 to 20,000 miles for negatives, 12,000 miles for Plante positives, and 6,000 miles for pasted positives. In other words, a 4 or 5-ton truck running 20 miles per day for 300 days in a year requires new positive plates once in a year, or once in two years, according to the type of plate used. Cabs and lighter wagons have about the same life with a capacity of 40 to 100 miles on one charge. Under these conditions experience has shown that the electric wagon gives better city service than can be gotten from gas or steam or horse. If a better battery than the lead cell was available on the market—either an improved lead cell or a better new one—it would control practically all city traffic not on rails.

#### ELECTROLYTIC DISSOLUTION OF SOLUBLE ANODES.

In a paper read before the American Electrochemical Society, WOOLSEY McA. JOHNSON made an attempt to co-ordinate the different factors which are of influence in the electrolytic dissolution of soluble anodes consisting of an alloy of different metals. In some respects his problem is the anodic analogon to the problem of cathodic reduction, dealt with by A. T. Weightman.

The fundamental facts upon which Mr. Johnson bases his theoretical considerations, are as follows: Every metal has a certain specific "electrolytic tension," or potential difference against an electrolyte, this potential difference depending on the nature of the electrolyte and the general physical conditions. Every metal has a specific electrical conductivity. These two properties—potential difference and conductivity—are profoundly modified by alloying with other metals. On these resulting properties of alloys segregated in the anode, depends the selective electrochemical dissolution of the anode.

In most cases alloys are formed with the evolution of heat; the resultant product is harder and has less tendency to dissolve. Further—and this is of greater importance—with the exception of several metals as zinc and cadmium, two metals unite to form an alloy the electric conductivity of which is smaller than that of either.

If, for instance, a particle of silver-copper alloy is considered which is surrounded by pure copper crystals; as the alloy has a much lower conductivity, it is to be expected that the current is shunted around the silver-copper alloy and finally dissolves its copper backing; it then can be brushed off into the "slime." On the other hand, if a "bi-metallic" anode is used, *i. e.*, a sheet of copper, by the side of which is a sheet of silver one two-hundredth of the size, it will be found that the silver dissolves at a much lower current density than in the case of the alloyed anode. The only difference in both cases is that in the first the silver is alloyed with the copper and not in the second.

Arsenic and antimony, if present as metals besides copper, would have a greater tendency to dissolve than copper, on account of their high electrolytic solution tension. But, in practice, for the same reasons which were just explained, they pass into the slime directly from oxidized anodes.

The author believes that much can be saved in copper refining by previous treatment of the anodes. A careful metallographical examination of the anode and some little thought on the alloys that can be formed, will reduce any electrorefining proposition to its simplest terms.

#### ON THE THEORY OF THE ELECTROLYTIC RECTIFIER.\*

By PROF. K. E. GUTHE.

An explanation of the peculiar phenomenon that an aluminum plate immersed in an alum solution will allow a large current to pass in one direction, but only a very small one in

the other, may be attempted from two different points of view. First, we may assume that the current, when the aluminum plate forms the anode, produces a non-conducting film *i. e.*, introduces an ohmic resistance, while this film breaks down with the current flowing in the opposite direction. Moreover its resistance must vary with the current strength, because it decreases apparently as the current towards the aluminum increases, *i. e.*, we have here an exact analogy to the so-called "resistance of transition," formerly supposed to exist in ordinary electrolytic cells.

The other point of view starts with the assumption of a very high electrolytic polarization (25 to 30 volts). According to this the ions are prevented by some cause, whatever it may be, from reaching the electrode and from giving up their electrical charges, unless they have obtained a certain amount of energy enabling them to overcome the obstacle. In favor of this latter conception—though the two do not necessarily contradict each other—may be mentioned, that a decrease in the size of the plate does not appreciably alter the current as we should expect, if the resistance were ohmic in its character.

So far the whitish, non-conducting oxide or hydroxide film on the plate has been held responsible for the formation of this high apparent resistance. But since no change can be found in the film under different conditions, and, since the resistance returns with remarkable regularity to the same value for the same current, the author considered the assumption of the formation and subsequent breaking down of the film as improbable.

He brought the plate, on which a high resistance had been produced, into a vacuum and found that a large number of minute gas bubbles appeared at the plate, showing the presence of a gaseous film. Removing this, at least partially, under the air pump, the resistance of the plate was greatly reduced.

The explanation given for the behavior of the aluminum rectifier is, then, that with the aluminum as anode the oxygen gas formed is kept in the meshes of the solid oxide film and thus prevents the passing of the ions, until by increasing the potential difference at the terminals of the cell, the energy of the ions is raised sufficiently to break through the gaseous film. On the other hand, the hydrogen produced by the current when flowing in the opposite direction is not held back in the solid network, but escapes freely. Consequently, we have no high resistance when the aluminum plate forms the cathode.

Some experiments were undertaken to prove the conclusions to be drawn from this theory. Increase of temperature decreases the apparent resistance. The concentration of the electrolyte does not influence the phenomenon. Different electrolytes depositing oxygen at the plate—solutions of alum, rochelle salt, ferrocyanide of potassium, copper sulphate and zinc sulphate—show all the same behavior. Anions, as chlorine, will not produce the high resistance, since they act in the same manner as hydrogen.

Since we have here a kind of a semi-permeable membrane, the author has examined the well-known membrane of copper ferrocyanide, deposited in a porous cup, and found it to act qualitatively the same way as the aluminum plate. In a cell, formed by: copper, solution of copper sulphate, membrane, ferrocyanide of potassium solution, platinum—only a small current could be obtained in the direction from the copper to the platinum, the counter *e. m. f.* of polarization rising as high as 20 volts, while the current would pass unobstructed in the opposite direction. A film deposited on a copper plate immersed directly in a solution of potassium ferrocyanide behaved in the same way.

In conclusion, it was pointed out that this theory might be able to explain ordinary polarization by the assumption of a liquid high-resistance film—possibly pure water—between the electrodes and the electrolyte; an explanation which would also facilitate our understanding of the peculiar fact, that hydrogen polarization appears to have very different values accordingly as it is deposited on platinum, lead or mercury.

\* Abstract of a paper read before the A. A. A. S. at the Pittsburg meeting, July, 1902.

## NIAGARA AS AN ELECTROCHEMICAL CENTRE.

### THE ELECTROCHEMICAL INDUSTRIES OF NIAGARA FALLS.

By JOSEPH W. RICHARDS, Ph.D.

*President of the American Electrochemical Society.*

(Concluded.)

#### THE PITTSBURG REDUCTION CO.

**T**HIS company were organized in 1888, by the late Capt. A. E. Hunt, to work the Hall process of producing aluminum. The chief investors were the Mellon Bank of Pittsburg and Messrs. Hunt and Clapp, of the Pittsburg Testing Laboratory. At present, R. B. Mellon, of Pittsburg, is president; Charles M. Hall and G. H. Clapp, vice-presidents; Arthur V. Davis, secretary and general manager. Originally, \$20,000 was subscribed to start the company, but at present the capitalization of the company is \$600,000 of 6 per cent. preferred stock and \$1,000,000 ordinary stock, paying 8 per cent. Mr. Hall lives at Niagara and has charge of the operation of the Niagara works.

There are two plants of this company at Niagara: the upper plant, situated on the grounds of the Niagara Falls Power Co.,



UPPER WORKS, PITTSBURG REDUCTION CO.

above the falls, and using 4,000 horse-power; the lower, situated on the edge of the gorge below the falls, and taking 6,500 horse-power from the Hydraulic Power and Mfg. Co.

The upper plant is situated half a mile above the upper power house, on a 10-acre plot of ground, and was the first plant to utilize this upper power. When, in 1893, the Niagara Falls Power Co. completed their power house, the next step of finding customers for the power was not easily solved, and special inducements were made to the Pittsburg Reduction Co. to break the ice and become the first plant to utilize this power. The offer took the shape of a contract to furnish the direct current needed for the process, at a certain price per horse-power per year, which price is a private matter between the two companies, but is understood to be not over \$18 per horse-power-year. This necessitated the installation by the power company of transformer machinery, at the reduction plant, which is owned and operated by the power company. This is, as far as is known to the writer, the only case in which this power company have furnished the current transformed to suit the customer's purpose, all subsequent contracts being at \$18 to \$20 per horse-power per year for the alternating current at 2,250 volts, the purchasers putting in and operating their own transformer machinery.

The alternating current is first passed through a set of twelve air-cooled stationary transformers, which reduce its potential to 115 volts and raise its ampérage correspondingly, with a loss in conversion of 3 per cent. It then passes to rotary transformers, of which there are six each of 800 horse-power, which transform the alternating current of 115 volts into direct current at 160 volts, with another loss of 3 per cent. in conversion. Five of these, run to full capacity, furnish two currents of approximately 10,000 ampères by 160 volts each; sometimes all six are run, at five-sixths full capacity, to furnish the same current.

Each current passes through a line of reducing pots, being conducted on aluminum bars, 12 inches by 1 inch, giving a carrying capacity of over 800 ampères per square inch of conductor. The bars are not insulated, the low voltage rendering that unnecessary. The voltage drop at each pot is a little over 5 volts, each pot absorbing about 65 horse-power. The current passes into each pot through carbon electrodes, 3 inches diameter by 18 inches long, each carrying 250 ampères of current. It is found that this is about the maximum current which can be carried by the copper-rod connections without undue overheating. About one-half the energy of the current is absorbed in the chemical work of decomposing alumina, the other half is converted into heat and keeps the bath at the proper temperature and fluidity necessary for electrolysis—about 850° to 900° Centigrade. The efficiency of recovery reckoned on the ampères used is between 80 and 90 per cent. The bath is the ordinary Hall bath, containing cryolite, to which is added aluminum fluoride, as the solvent, and with alumina dissolved therein. The action of the current sets free aluminum and oxygen, the latter uniting with the carbon anodes to carbonic oxide. Although 4,000 horse-power are being used, the smell of fluorine is usually not perceptible in the pot room, except during casting or trimming up a pot. The aluminum obtained averages 0.1 per cent. iron, 0.3 per cent. silicon, with smaller amounts of copper, titanium, carbon and sodium, but is guaranteed over 99 per cent. pure, averaging more nearly 99.5 per cent. The selling price of such metal is, in ton lots, 31 cents per pound; less pure metal is made from less pure alumina, and sold, for use in casting iron and steel, at 2 cents per pound less.

The main reduction room is an iron building, 180 by 85 feet, with a high roof. The windows are whitened by the hydrofluoric fumes occasionally escaping, but the fumes in the building are seldom strong enough to be perceptible. The metal is run into rough ingots, weighing 20 pounds each, and the total output from this plant must be in the neighborhood of 7,200 pounds daily. The crude ingots are shipped to New Kensington, Pa., to be remelted and converted into commercial shapes.

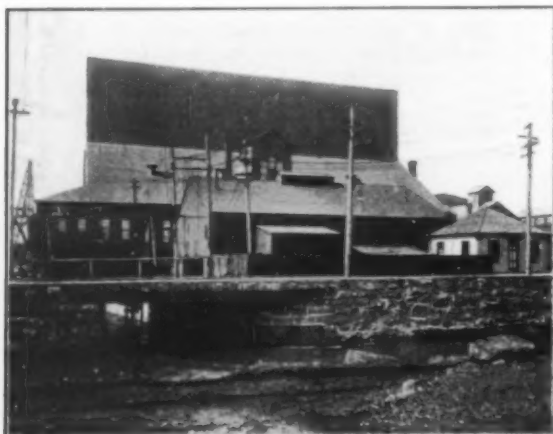
Alongside this main room is a building of equal area, but not so high, in which are kept the stock of metal, and also stocks of alumina and carbons. It contains furnaces for baking the carbon lining in the pots, and machinery for drilling and repairing the carbon electrodes. There is also a well-equipped laboratory, presided over by Wm. T. Whitten, with several assistants.

The company own large deposits of bauxite, the native hydrous aluminum oxide, in Georgia and Alabama.

In 1900 Mr. Hall invented an entirely new method of commercially purifying alumina (U. S. Patents 677,207, 677,208, 677,209, of June 25, 1901), which will receive its first commercial application at Niagara Falls. The bauxite is mixed with sufficient reducing agent, such as carbon, to reduce all the impurities in it to the metallic state, i. e., silica to silicon,



titanic oxide to titanium, iron oxide to iron. The mixture is then melted in an electric furnace, using a carbon pole, the material itself being fed into the arc, and the melted alumina constituting the other pole. An alternating current of low voltage is used. The impurities collect as a metallic alloy of iron, titanium and silicon, while the purified alumina above is almost chemically pure. The furnace is let cool and the contents separated when cold. It is estimated that in this way the bauxite can be purified at less cost than by the wet, chemical processes. The alumina produced is granular, heavy, dissolves well in the pots and produces a metal of high purity.



LOWER WORKS, PITTSBURG REDUCTION CO.

The lower plant of the Pittsburg Reduction Co. is situated on the edge of the gorge, one-quarter mile below the steel bridge, and immediately above the power house of the Hydraulic Power and Mfg. Co. The current is generated in the power house, as direct current, by means of Westinghouse dynamos of 750 horse-power each, coupled direct to turbines with horizontal shafts, the current being conveyed on aluminum cables, of 28 square inches sectional area, a distance of 250



THE CARBORUNDUM CO.

feet to the reduction room on the bank. Each dynamo gives a direct current of 2,000 ampères, at a potential of 280 volts, and nine such machines furnish the 6,500 horse-power necessary to run three lines of pots (2 lines are run at the upper works by 4,000 horse-power). The method of reduction is exactly the same as at the upper plant, and the output approximately 50 per cent. greater, making the total output of both plants probably 19,000 pounds per day. The building has its roof extended into an enormous ventilator, giving it the appearance of a grain elevator, but this greatly increases the com-

fort of the workmen. No other work than reduction is performed here, for which a force of about 150 men, working in eight-hour shifts, suffices. At the upper works the force is about 200.

Besides these works this company have recently extended their plant by the installation of 5,000 horse-power at Shawinigan Falls, Quebec, and the acquisition of 12,000 horse-power and 100 acres of ground at Massena, N. Y., on which an aluminum plant will be erected. Our congratulations to the enterprising pioneers of the aluminum industry in America!

#### THE CARBORUNDUM CO.

This company also owe their organization to Pittsburg capitalists, who in 1893 organized them to work the processes of A. G. Acheson for producing carborundum. The present officers are: F. W. Haskell, president; F. J. Tone, works superintendent, and among the larger stockholders are A. W. and R. B. Mellon, Pittsburg; A. G. Acheson and G. R. Rayner, Niagara Falls.

Carborundum is carbon silicide,  $CSi$ , and is formed by intensely heating, in an electric furnace, a mixture of carbon, sand and salt. Mr. Acheson first made it while trying to melt



A CARBORUNDUM FURNACE.

carbon and clay together, and to crystallize out the carbon, and obtaining some bright blue crystals in this manner, which were certainly not pure carbon, he suspected that they were a compound of carbon and alumina, and constructed for them the name *carborundum*. Analysis, however, showed these crystals to contain 60 per cent. of silicon, 30 per cent. of carbon and only 4.78 per cent. of alumina. Experiments then followed with mixtures of carbon, silica sand and salt as a flux, and large crystalline masses of the new product were obtained. Its hardness suggested its use as an abrasive, since it is nearly as hard as the diamond, and its commercial manufacture as a substitute for emery and corundum soon followed.

The furnaces employed at Niagara Falls are horizontal, and take 1,000 horse-power each. There are two blocks of five furnaces each, of which one furnace in each block is in operation, while the other four are either cooling off, being emptied

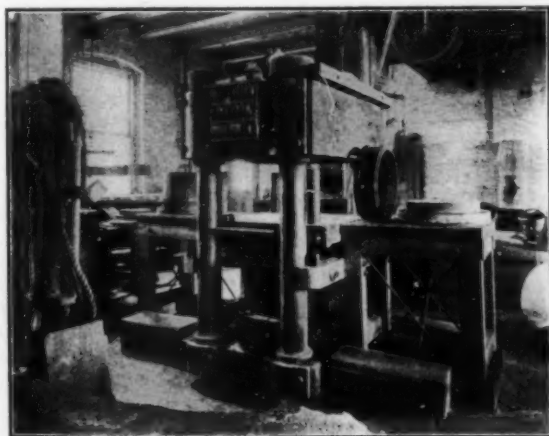
or being loaded up for a fresh run. The bed of fire brick is 16 feet long, 5 feet wide and stands 2 feet above the floor. The ends are of solid brickwork, 2 feet thick and 8 feet high, in the center of which are square iron frames, in which are drilled holes. Through these holes the strands of the conducting copper wires pass, and are connected to the terminal carbons, bunched together, which lead the current into the furnace. Directly in contact with these carbons is placed the conducting carbon core, which conducts the current through the furnace



CARBORUNDUM.

and by its resistance raises the temperature sufficiently to reduce the carborundum-making mixture which surrounds it. When charging is completed, the carbon core is surrounded on all sides by the mixture to a distance of 2 to 3 feet, and the top is rounded off like a mound. The electrical connections are now made to the iron frames, at the extreme ends of the furnace, and the charge is ready to burn.

The alternating current of 250 volts is passed into a 830 kilo-watt (1,100 horse-power) stationary transformer, which



A CARBORUNDUM PRESS.

cuts its voltage down to an average of 185 volts. A regulator allows the current to vary from 100 volts up to 250, while the amperes vary from 2,000 up to 8,000. The 4 per cent. loss in transformation, representing 40 horse-power, would heat up the transformer, but is counteracted by cooling it by circulating currents of oil.

The furnace starts at high voltage and low ampérage, because of the poor conductivity of the carbon core when cold. The total contents of the furnace are about 1,000 pounds of

carbon core, and the mixture reduced represents 3.5 tons of carbon mixed with 6 tons of silica sand and 1.5 tons of salt, producing in a thirty-six-hour run between 3 and 4 tons of commercial carborundum, in crystals, outside of which is a quantity of light-green amorphous carborundum, fully reduced, but uncrystallized, and outside of this the unchanged mixture. Near the carbon core, where the heating is most intense, are found some crystals of carborundum from which the intense heat has volatilized the silicon, leaving a skeleton crystal of graphite, while the silicon, passing outward as vapor, oxidizes to spongy, felt-like silica as soon as it meets carbonic oxide gas. Some of the vapor has been found condensed to metallic silicon in cracks in the bed of the furnace. The observation of the formation of graphite by the very evident decomposition of the silicon carbide, was the starting point of the graphite industry now conducted by Mr. Acheson in an adjacent plant.

A third block of furnaces is now in course of construction, which will raise the power requirement to 3,000 horse-power,



A CARBORUNDUM KILN.

and increase the output of carborundum to 1,800 tons per annum.

The furnace, after a run, is allowed to cool several hours, then gradually uncovered, the unreduced mixture is removed, the reduced, but uncrystallized, carborundum is put aside to be mixed with another charge, and the 10 to 15 inches of well-crystallized carborundum next to the heating core is carefully gathered up. The carbon core serves only as a heating agent; very little of the current during reduction passes through the sand-carbon mixture, which is in reality a very poor conductor of electricity. The process is, therefore, simply that of heating the mixture to be reduced by the heat generated in a carbon conductor, which carries the current and which is surrounded by the mixture. The electric current not only heats up the immense mass of charge, but also supplies the heat absorbed in the chemical reactions involved. A consideration of the power used and the products obtained in one run, leads to the conclusion that about 25 per cent. of the energy of the current is needed to heat the materials up to the

reacting temperature, 50 per cent. in supplying the great quantity of heat absorbed in the chemical process of reduction and only some 25 per cent. is lost by radiation during the run (the 25 per cent. first spoken of is lost by radiation after the run has ended).

The cost of power alone amounts to 1.25 cents per pound of crystals obtained, the cost of materials for the mixture 0.75 cent and labor probably another 0.5 cent, making the estimated cost of crude crystals 2.5 cents per pound. This material must be otherwise treated before being ready for market. This subsequent treatment consists in crushing the masses to coarse powder, allowing this to stand several days in dilute sulphuric acid, to remove any such impurities as iron oxide, then washing and grading. The final cost of the powder or grains may be 4 to 5 cents per pound. It is sold at an average of 9 cents per pound; the manufacture of 2,400,000 pounds yearly providing, therefore, an estimated profit of \$100,000 to the company. A large part of the product is, however, worked up by the company themselves into wheels, hones, etc., of all sizes and descriptions, the manufacture of which occupies, with its presses, baking ovens, kilns and stock rooms, the greater part of the floor space in the company's factory. This manufacture is an additional and large source of profit.

The crystals are graded in 20 sizes, from No. 8, passing



INTERNATIONAL ACHESON GRAPHITE CO.

through 8 meshes to the linear inch, to No. 220, passing through 220 meshes to the linear inch. The washings from the finest crystals pass into settling tanks, producing so-called *carborundum flour* of three grades of fineness, F, FF and FFF. The finest powders are made by stirring fine powder or flour in water, letting it settle a definite time, one, four, six, ten or fifteen minutes, decanting the liquid and then settling the powder from this by long standing. Such powders are called *hand-washed* one, four, etc., minute powders.

The factory buildings are two and three stories high, covering three sides of a four-acre plot of ground, and contain 120,000 feet of floor space. They contain costly machinery, presses, drills, etc., for making the carborundum up into wheels, sticks, hones, sharpening stones, cloth, paper, etc. The greater part of these goods are made up with a bond of kaolin and feldspar, which becomes vitrified in the subsequent kiln burning, producing the firmest "body" which can be made.

A particular use to which carborundum has been put is the addition to steel, to secure sound castings, it being thus possible to introduce silicon without bringing a trace of phosphorous or sulphur into the steel. Since the carborundum contains 70 per cent. of silicon to 30 per cent. of carbon, it is very efficient for this purpose.

Immediately in front of the factory is the new office, built in colonial style after designs of Mr. Haskell, president of the company, and one of the prettiest office buildings in Niagara.

#### THE INTERNATIONAL ACHESON GRAPHITE CO.

Manufactured graphite was suggested as a commercial possibility to Mr. Acheson by finding in the center of his carborundum furnaces masses of graphite resulting from the overheating of carborundum. The making of carborundum is a delicate operation, the proper adjustment of current to core being absolutely necessary for producing a good output. It has been stated that an increase of 3 per cent. in the size of the conducting core, in a carborundum furnace will result in a great decrease in the amount of carborundum formed, because of deficient temperature, while an increase of 3 per cent. above the normal will result in the conversion of considerable carborundum into graphite, by volatilization of its silicon. In other words, the temperatures of formation and of decomposition of carborundum lie somewhat close together, probably not over 500° Centigrade apart.

Having thus an idea of a new principle which was available for producing graphite, Mr. Acheson experimented further, with the result of becoming convinced that all metallic carbides, on being decomposed by heat, leave behind graphite, and his patents and process are based upon that fact.

The company concerned was organized in 1899, with Mr. Acheson, president; A. W. Mellon, Pittsburg, vice-president, and P. McN. Bennie, secretary. The patents by which they work are U. S. Patent 542,982, of July 23, 1895, which relates to the production of pure electric-light carbon by subjecting impure carbon to a high temperature for a sufficient length of time to volatilize its impurities; U. S. Patent 568,323, of September 29, 1896, and 617,979, of January 17, 1899, which disclose the principle of converting carbon into graphite by mixing it with such metallic oxides as would be capable of forming metallic carbides, to be subsequently decomposed; U. S. Patent 645,285, of March 13, 1900, which claims the use for conversion into graphite of such natural carbonaceous materials as contain uniformly intermixed through them metallic oxides sufficient to produce carbides and thence graphite. These patents, taken together, not only form the basis of the commercial manufacture of graphite, but throw much light on the scientific question as to the manner of its formation.

The furnace building is of brick and iron, 100 x 50 feet, and contains two rows of five furnaces each. Back of this is a frame building with machinery for grinding coke and coal, and making the furnace mixtures. The power used is 1,000 horse-power, converted down from 2,250 volts to an average of 150. The blocks are run very much like carborundum furnaces, in that while one furnace is being run, the four others are in various stages of dismantlement or re-filling. The commercial work of the company has resolved itself into two lines of manufacture: (1) the graphitization of molded carbons, (2) the graphitization of anthracite coal *en masse*. The product is, in either case, pure graphite, which should be known as *manufactured* graphite rather than *artificial* graphite, since it is no counterfeit of graphite, but the real graphitic carbon itself. A good summary of the history of the invention, by Mr. Acheson himself, may be found in the *Journal of the Franklin Institute*, for June, 1899, and a discussion of the value of the resulting product, by Mr. Collins, in the *Transactions of the American Electrochemical Society*, Vol. I, 1902.

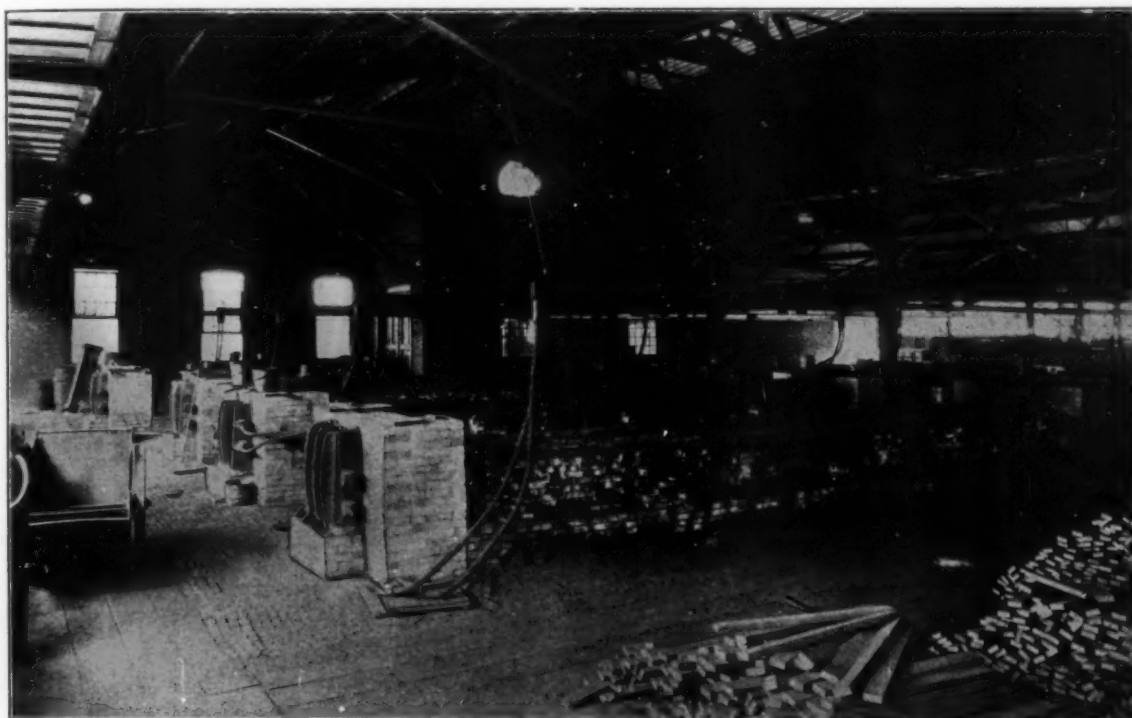
The conversion of molded carbon articles into graphite is performed by stacking them transversely to the current in a pile about 2 feet square, between terminals 30 feet apart, and covering them thickly with fine granular carbon and carborundum. A quite recent patent to Mr. Acheson (U. S. Patent 702,758, of June 17, 1902), has for its subject-matter the particular manner of stacking such articles for graphitization, the granular carbon between the articles being the principal heat-producing agent, while the heat generated in the articles themselves is of secondary value because of the transverse position of the articles. By this arrangement the furnace charge offers such resistance to the current that it may



be held at a very high temperature, while the conducting terminals, of solid carbon, but of much smaller cross section than the furnace charge, are at only a moderate temperature. (This is also discussed by Townsend in the *Electrical World*, of June 28, 1902.) The current is then put onto the furnace, at 220 volts and 3,000 ampères to start with, and gradually increasing to 80 volts and 9,000 ampères at the end of a twenty-hour run. At the close of the run the furnace is allowed to cool off several hours before uncovering. The heat is thus sufficient to graphitize the furnace charge completely and also even some of the outer packing of granular carborundum. If the articles have not been heated sufficiently, they will still contain some amorphous carbon, which will dissolve in acids and alkaline solutions, and disintegrate the article; if they are overheated they may become too dense and develop cracks on cooling or subsequent use. Many hundred thousand of carbon electrodes, 15 inches long by 1 inch cross section, used in the liquid caustic alkali process, have been made in this way,

phous carbon into graphite is, of itself, a heat-evolving reaction, such that the graphitization of 7,000 pounds of carbon would represent  $7,000 \times 236.5 = 1,655,500$  pound-calories ( $1^\circ \text{C.}$ ) or some 5.7 per cent. of the energy which the current furnishes, but against this can be set the heat necessary to reduce metallic oxides and dissociate carbides, which will be a factor of about the same value.

As to the articles thus graphitized, they possess a specific resistance of but 0.00032 ohm per cubic inch, which is but one-fourth that of amorphous carbon. (This specific resistance is 0.0008 ohm per cubic centimeter, and since that of mercury is 0.000094 ohm, the conductivity is 11.75, mercury being 100, or 0.21, copper being 100). As for durability, such carbons have been used as anodes in alkaline chloride solutions for three years, with a current density of 50 to 250 ampères per square meter, without as much as rounding off the sharp edges. In electric-furnace work, at high temperatures, the consumption by oxidation is one-fourth, or less, that of



GRAPHITE FURNACES, ACHESON GRAPHITE CO.

and have given such satisfactory service that Mr. Acheson's business has really suffered by the surprising long life (one to two years) of these electrodes and the consequent lack of renewals. Blocks, 8 inches by 10 inches and 4 inches thick, as well as rods, 4 inches square by 24 inches long, have been perfectly graphitized in these furnaces.

Since three to three and a half tons of material can be graphitized in one charge, with nearly an equal amount of granular carbon and carborundum on the furnace, we can calculate, from a consideration of the current used, that it would take the current used over sixteen hours to bring the furnace up to the volatilizing point of carbon, which is not far above the temperature of graphitization. The current being run for twenty-four hours, it follows that just about one-third of the total heat energy of the current is radiated or conducted away during the run, while two-thirds are represented by the heat in the hot furnace at the end of the run, the heat in the actual articles being graphitized being 40 per cent. of the heat energy of the current. The conversion of amor-

amorphous carbons under similar circumstances, making their use in many cases very advantageous.

The other line which the electrical manufacture of graphite has taken, is the conversion of carbon in bulk into graphite. For this purpose some carboniferous material is taken which has a considerable quantity of ash, or metallic oxide impurities, uniformly distributed through it. The purest carbon, such as petroleum coke, which contains only 0.3 per cent. of ash, graphitizes very poorly; similarly, ordinary coke will graphitize completely only where the ash is uniformly distributed, but those parts of the coke which have been formed from the baking of exuded pure bituminous matter are too pure to graphitize and yield a poorly-converted product. Clean anthracite coal, such as washed *pea* or *buckwheat* coal, are the best adapted, and give very satisfactory results, for in them nature has distributed 5 to 15 per cent. of ash with almost molecular uniformity.

The furnace for this conversion is 30 feet long and is formed of a trough 2 feet square, lined on bottom and sides with blocks

of compact carborundum 6 inches thick. This is found to be a very satisfactory lining for high-temperature electric furnaces, to build walls in places where the best fire brick would melt like water and carbon bricks would be subject to oxidation. The coal is ground to about the size of rice and the furnace trough first half filled. Graphite rods are inserted in the ends, to conduct the current into the mass, and a core of granular carbon, partly graphitized, about 6 inches wide, is laid from one end to the other, in order to start the current, since cold anthracite is of itself so poor a conductor that, otherwise, it might be impossible to start the current flowing with the maximum volts at command. The furnace is then filled up, and a layer of coarse carbon and granular carborundum placed on the top. The charge of anthracite is about six tons, and it is graphitized in twenty hours. A consideration of the energy of the current and the amount of material treated lead to the conclusion that about 82.5 per cent. of its energy is consumed in raising the charge to the graphitizing temperature and 17.5 per cent. radiated during the run; or, stating it another way, it requires theoretically sixteen hours and thirty minutes' running to bring the whole charge up to the graphitizing temperature, and the rest of the twenty hours is used in keeping it there and supplying radiation. The heat evolved in conversion of amorphous carbon into graphite amounts in this case to fully 10 per cent. of the heat supplied by the current, but this is just about balanced by the heat absorbed in volatilizing the 5 to 10 per cent. of impurities from the coal.

The amount of unconverted amorphous carbon is most easily estimated in the laboratory by attacking it with concentrated nitric acid at 86° C., when the brown coloration of the liquid gives the means of estimating the amorphous carbon present. Natural graphite contains some amorphous carbon, say 0.1 to 0.2 per cent.; the manufactured graphite from anthracite coal may contain up to 2 per cent., the graphitized articles to which have been added iron oxide to facilitate conversion, contain often as little as the native graphite.

Many kinds of graphite may be produced from different carbonaceous materials treated in different ways and crushed afterwards in different manners. There is the soft and the dense, the laminated, foliated and stratified kinds, the fibrous, like Ceylon wood graphite and the sealy, like Ticonderoga graphite. Different kinds are suitable for different purposes; the sealy for crucibles and lubricating purposes, the dense for hard lead pencils, the soft for foundry facings, stove polishes and iron-protecting paints. The total yearly production of this factory is nearly 1,000,000 pounds, at an average value of 8 cents per pound; graphitized electrodes are valued at 12 to 15 cents per pound and graphite in bulk from 10 down to 4 cents, according to purity and flakiness, and the product represents a considerable fraction, some 20 per cent. of all the graphite produced in America.

#### THE ACKER PROCESS CO.

The projectors of this company are the brothers C. E. Acker and A. E. Acker, who began in 1894 experimenting at the problem of electrolyzing melted sodium chloride, and producing thereby caustic soda and chlorine. An extensive description of the process which has been evolved, written by C. E. Acker, is in the *Transactions of the American Electrochemical Society*, Vol. I, 1902. The patents under which the company work are U. S. Patents 649,565, of May 15, 1900; 674,691, of May 21, 1901, and 687,709, of December 3, 1901, to Chas. E. Acker.

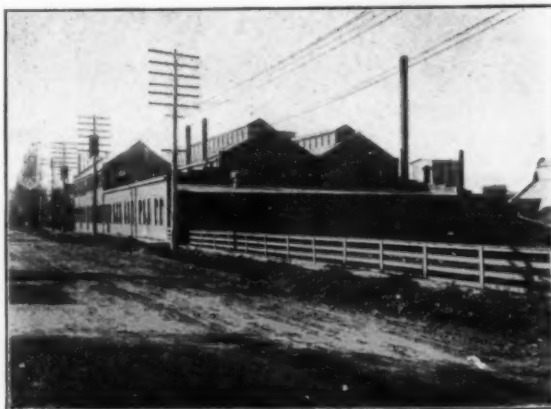
The plant established at Niagara Falls is situated 1,500 feet below the lower power house, on a 10-acre piece of ground, and comprises a large reduction room, some 80 by 150 feet in plan, a still larger building of brick and iron for the bleaching powder plant, besides an extensive machine shop, brass-casting foundry, pattern shop and large offices. Some 250 men are in the company's employ.

The idea of Acker's process, and elaborated in his patents, is the electrolyzing of melted sodium chloride resting upon melted lead, the latter serving as cathode. The lead-sodium alloy is then decomposed by a jet of steam in another part of the same apparatus, producing melted caustic soda, which flows away and hydrogen which immediately burns. The process is carried on in a heavy cast-iron vessel, 5 feet long, 2 feet broad, with a bowl about 12 inches deep. The sides, above the surface of the melted lead lying on the bottom, are protected by a lining of magnesia blocks. At one end is a small compartment separated by a partition dipping below the level of the lead, into which the lead alone can pass and in which



ACKER PROCESS CO.

it meets a jet of steam blown directly into it, which oxidizes the sodium to caustic. On top of the lead a bath of sodium chloride is melted, about 6 inches deep, into which dip four graphitized carbon blocks serving as anodes. The lower surface of these blocks are 14 inches long by 7½ inches wide, and reach to within ¾ inch of the melted lead. The blocks are 3 inches thick and are kept in place by heavy 5-inch round graphitized carbons, 12 inches long, two of which are screwed into each carbon block. The upper end of these rods are encased in fire-brick-tiles, which, when in place, form part of the cover of the furnace, and electrical connection is made by

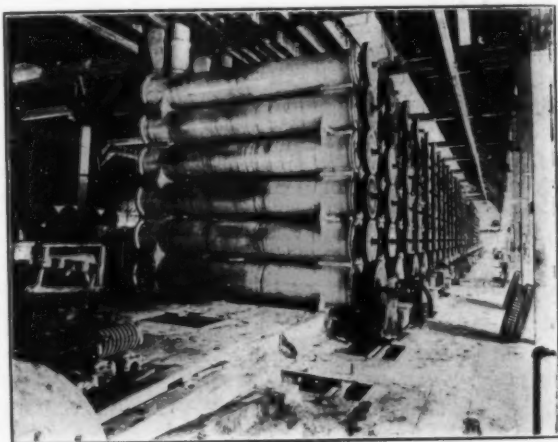


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means of heavy brass rods, 1½ inches in diameter, tapped into them, and connecting further up with copper rods, which are held by clamps to the bus bar above. The 5-inch rods are protected by fire-clay sleeves, joints are plastered over with cement. The top of the furnace is further loosely closed by fire-clay slabs, but the joints need not be very tight, since the chlorine is drawn away by side flues by a strong exhaust, making the escape of chlorine into the room impossible. The

salt to be used for charging comes through a hopper from the floor above, and is piled between the furnaces and on part of the cover, so as to become dry and warm before being charged.

The pot room has place for 54 furnaces, in four rows, of which 40 to 45 are in action while the others are undergoing repairs. The current of 3,000 horse-power is sent 1,500 feet from the generating station as direct current of 8,200 ampères, reaching the works at a potential of 275 volts, the cables in the conduit being half the way copper and half aluminum. The pots are all run in one series, so that the drop of voltage is between 6 and 7 volts per pot. The four electrode blocks carry, therefore, about 2,100 ampères of current each, which gives a current density at the lower surface of approximately 2,750 ampères per square foot. This keeps the temperature of the bath at 850° C., a cherry red, which is 75° above the melting point of the salt. The object in conducting the process is to keep as nearly as practicable to the melting point of the salt, in order to avoid the re-solution of sodium and the re-combination which takes place at higher temperatures. The melted salt looks slightly syrupy, and has a silky sheen like melted metal. The workmen regulate the temperature by raising or lowering the electrodes and by charging fresh salt as



BLEACHING POWDER CYLINDERS, ACKER PROCESS CO.

the level of the bath sinks, and they have frequently to break with a bar the crust which solidifies between the carbon rods. The salt is from the neighboring New York salt beds, costs \$3 per ton and is not purified before use. The bus bars, for carrying the current, are of copper, and of 9 square inches section, giving 900 ampères per square inch, which is very ample carrying capacity, since aluminum conductors, with only two-thirds the conductivity, are sometimes loaded quite as heavily.

The steam jet, in the compartment at the end of the pot, is introduced beneath the surface of the lead, but pointing vertically upwards. The jet strikes a curved hood, which brings the material down into a third compartment, about 6 inches by 10 inches in area, in which the lead and caustic separate, the latter flowing out of the furnace over a cast-iron lip, the lead sinking and passing back into the reduction compartment of the furnace, while the hydrogen evolved issues from the spout, burns and is conducted away by a 6-inch sheet-iron pipe to a chimney. The melted caustic runs into a sheet-iron pan, where it sets, and is removed every hour. The average output of a furnace is a 25-pound cake hourly. The theoretical amount of caustic which the current should produce being 26.9 pounds per hour, in each pot, the average efficiency obtained is thus seen to be 93 per cent. The voltage used, however, is the other factor of the process which needs considering. There is required, theoretically, 4.2 volts to decompose sodium chloride into sodium and chlorine, but since the sodium unites with lead with great avidity, it is probable that the production

of the alloy requires 3.5 volts. Since 6 to 7 volts are used per furnace, we have an average of 3 volts converted into heat. Of this heat evolved, calculation shows that one-sixth is utilized in melting the fresh salt added, while five-sixths is lost by radiation and conduction, and resistance of conductors and connections. Or, considering the whole energy of the current, we may say that 54 per cent. of it is utilized in the chemical reaction, 7 per cent. in melting the salt added and 39 per cent. is lost by radiation and conduction.

The cakes of solidified caustic are taken out of the pans and slide down a chute directly into the cast-iron melting pots, 8 feet in diameter. Here it is melted, allowed to stand six hours to settle and bailed out into sheet-iron drums, 2 feet in diameter by 4 feet high, holding 750 pounds each. The total product is 23,000 pounds of caustic per day.

The chlorine gas is drawn by a powerful fan, 15 feet in diameter, motor driven, through a series of 30 Hassenclever absorption apparatus, each consisting of six drums above each other, 2 feet in diameter by 20 feet long, in which screens revolve slowly in alternate directions. The 50 pounds of slaked lime fed per hour into the upper cylinder is gradually passed by the screw motion from one cylinder to the other, until in twenty-four hours it arrives at the discharge hopper, while the chlorine gas, mixed with air, passes in the opposite direction through the apparatus and into a scrubbing tower beyond, where the last traces of chlorine are removed. The total plant takes care of 21,000 pounds of chlorine daily, requiring 36,000 pounds of slaked lime and producing 57,000 pounds of bleaching powder.

With salt costing \$3 per ton and power \$15 per horse-power per year, the cost of raw material for making a ton of caustic soda is \$4.50, the cost of power \$11, steam and remelting 50 cents, labor and repairs probably \$14 or an estimated total of \$40, which is to be diminished by the value of the chlorine for making bleaching powder. Every \$1 per ton profit made on the sale of the bleaching powder would mean \$2.50 per ton reduction on the net cost of the caustic. Compared with the aqueous processes, Acker's process consumes more power and costs more in replacement of apparatus, but takes less expensive plant and apparatus, and dispenses with the boiling down of the caustic solutions.

We wish success to the manufacturers in both lines.

### STATISTICAL.

In a circular, issued by the authorities of the Universal Exposition to be held in St. Louis in 1904—Prof. W. E. Goldsborough being the chief of the Department of Electricity—the following statistical data are given:

Number of electroplating establishments, 500.

Capital invested in electric mining and power transmission properties, \$200,000,000.

Capital invested in electroplating and depositions, \$50,000,000.

Capital invested in "automobile and electric storage batteries," \$25,000,000.

Total amount invested in electrical industries, \$3,975,000,000.

Electrolytic production of copper, 200,000 tons per year.

Electrolytic production of gold, 170,000 ounces per year.

Electrolytic production of silver, 12,000,000 ounces per year.

It is not stated whether these figures refer to the United States alone, or to the whole world. But from the figures given for the electrolytic production of copper, it is evident that the United States alone is meant. The figure for the electrolytic production of silver does not seem to be correct, as in the latest volume of *Mineral Industry* (Vol X, page 228) the estimated daily output of three electrolytic silver refineries, in operation in the United States in 1901, is given to be 125,000 ounces Troy. If one assumes only 300 working days per year, the yearly amount of electrolytically-refined silver comes out as 37,500,000 ounces, i. e., more than three times the amount stated in the pamphlet.



## PIONEERS OF ELECTROCHEMISTRY—II.

ALFRED H. COWLES.

Alfred Hutchinson Cowles, second son of the late Edwin Cowles, founder and editor, until his death, of the *Cleveland Leader*, was born in Cleveland, Ohio, in December, 1858. His mother, Elizabeth Hutchinson Cowles, fully shared her distinguished husband's appreciation of education, and Alfred Cowles, like his brothers and sisters, was given large opportunities to follow his bent for study. He attended the public schools of his native city, and later he spent two years at the Ohio State University, at Columbus, making chemistry and metallurgy his special studies. From this institution he went to Cornell University, and remained there four years, continuing to devote himself to science.

At Cornell Alfred Cowles became active in rowing, being the captain of the 'varsity crew in his senior year, and going with it to Europe, where the Cornell oarsmen raced at Henley, for the famous Stewards' Challenge Cup, at Putney and on the Danube. But chemistry, metallurgy and physics remained the chief interest of his life, as they have been to the present date.

After leaving college, Mr. Cowles spent some time in New Mexico, in the development of mining property owned by his father. When hardly more than a boy he invented an improved backing, still in general use, for matrices in newspaper and other stereotyping. Then, as at all times since, science and invention left room for the general interests of a man of affairs, largely interested in a great newspaper and accustomed from childhood to the consideration of public questions and important concerns of many kinds.

But the chief pursuit and interest of seventeen years for Mr. Cowles has been the electric smelting of aluminum and the researches and discoveries in electrochemistry and physics which have attended and grown out of that central subject of study and experiment. In connection with Eugene H. Cowles, an older brother, the subject of this sketch revealed and developed the great possibilities of the electric furnace, especially in the production of aluminum and alloys of that metal. The Cowles Electric Smelting and Auminum Co. were organized and works were built in 1885 at Lockport, N. Y., where extensive water-power could be obtained. By means of the electric furnace, first used commercially by Alfred and Eugene Cowles, and brought by them before the world of science, as well as business, alumina and many other minerals, some of them rare and refractory, were disrupted for the first time by any other than a chemical laboratory process.

Patents were taken out in Great Britain, Germany and other foreign countries, and a company were organized in England to produce aluminum and its alloys.

Between 1885 and 1890 the Cowles Co. offered aluminum, for the first time anywhere in the world, in cheap form and com-

mercial quantities, although almost wholly in alloys, especially bronze.

Out of this business sprung many important discoveries in electrochemical smelting. Among the results are calcium carbide, which is said to have been produced, in a small way, in the Cowles electric furnace while it was used in Cleveland. Thomas L. Willson, who was then employed in the Brush Electric Works in that city, later developed the production of calcium carbide on a commercial scale at Spray, N. C., and from this source, since greatly enlarged and improved, has come the supply of acetylene gas for various purposes.

Carbon bisulphide is now made on a large scale at Penn Yan, N. Y., by Chas. B. Taylor, formerly of Cleveland, by the adaptation of the electric furnace to an industry which depended, until that furnace came into use, on chemical means of production. At Niagara Falls phosphorus is produced by a process which is said to be an outgrowth of the Cowles discoveries. It is the direct result of the researches and inventions of Dr. Redman, employed at the works of the British "Cowles Syndicate" when that company were located at Stoke-on-Trent.

Another notable development from the electric furnace has been the carborundum industry, now attaining large proportions at Niagara Falls. In 1890 Edward G. Acheson, a young student and experimenter from the laboratory of Thomas A. Edison, undertook, by the use of the electric furnace, to make diamonds. He produced hard, lustrous crystals, composed of carbide of silicon, and found them commercially available as a substitute for emery and other abrasives. From this beginning an important business has developed, but it is said that the foundation for it was laid in 1884, when Alfred Cowles and his brother, now many years deceased, are said to have first produced carborundum in their electric furnace in Cleveland.

In the early days of the Cowles Electric Smelting and Aluminum Co. their experiments and improvements did important pioneer work for the United States and for other countries in the use of large dynamos.

The development of the aluminum industry by the Cowles Co. has been much impeded by prolonged and costly litigation, begun in 1891, over certain fundamental patents. Four great cases have been contested in the United States courts, and two have been carried to a final decision in favor of the Cowles interests. The others are awaiting a hearing in the Circuit Court of Appeals, after decisions adverse to the Cowles side in the lower courts.

The work of Cowles has resulted in the production of many articles in common use, from the lamps on bicycles to aluminum for the transmission of electric energy.

Alfred H. Cowles is still active and fertile in scientific research, and his studies run into fields of investigation and discovery widely different from that which has been the main interest of his life.



*Alfred H. Cowles*

## NIAGARA FALLS MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY.

THE second general meeting of the American Electrochemical Society, held at Niagara Falls, N. Y., from September 15th to 18th, turned out to be a splendid success in every respect. The actual attendance at several of the meetings was nearly 200, while the number of members and guests registered was 164, an alphabetical list of the latter being given on another page of this issue.

The local committee, comprising the Niagara Falls members of the Society, with Chas. M. Hall as chairman, and a ladies' committee, with Mrs. Chas. E. Acker as chairman, had arranged an extensive programme for the different days of the meeting, and did everything in their power to make the visitors feel at home. A search-light trip over the Niagara Gorge trolley line to Kingston and back, on the evening of September 16th, was especially enjoyable. On the evening of September 17th the local committee gave an elaborate banquet to the members and guests of the Society at the International Hotel. This was followed by dancing in the hotel parlors. Wm. B. Rankine, who presided as toastmaster at the banquet, responded to the toast "Niagara Falls;" President J. W. Richards to the toast to the Society; Prof. Haber spoke for the German Bunsen Society and R. S. Hutton for the electrochemists in Great Britain; Prof. W. D. Bancroft responded to the toast "Our Universities;" Prof. F. B. Crocker to a toast on the sister societies, and Dr. N. S. Keith to a toast on the ladies. The banquet was attended by 150 persons.

Some disappointment was being felt on account of the fact that the managers of most of the electrochemical plants of Niagara had previously decided to keep up their old policy of secretiveness, and not to open the doors of their workshops to the members of the Society. Only four electrochemical works made an exception, and their courteous invitation was greatly enjoyed. They were the International Acheson Graphite Co., the Carborundum Co., the Electrical Lead Reduction Co. and the Atmospheric Products Co. The same courtesy was extended by the Niagara Power Co., the Hydraulic Power and Mfg. Co. and the Natural Food Co. The visits to these plants were very enjoyable, and while they represented only a small percentage of all the plants, it is perfectly true that on the whole the members of the Society saw more in Niagara than they can ever see at any other single place in the United States.

From official statements given out at the meeting, it appears that the financial conditions of the Society are in a fairly good shape. The number of members, including the applicants to be elected at the next meeting of the Board of Directors, is 433. The New York members, through A. von Isakovics and Dr. N. S. Keith, extended a courteous invitation to the Society to hold the next meeting in New York City, in the spring of 1903. This meeting will be the annual business meeting, while the Niagara convention was devoted entirely to scientific and technical matters. Technical sessions were held on every morning of the four days the convention lasted, and, in addition, in order to get through the whole programme of papers, it became necessary to hold a session on the afternoon of September 17th. In the following we give a concise review of the proceedings:

### MONDAY'S SESSION.

The first paper presented to the Society was by FRANCIS A. J. FITZGERALD, on "Testing Carbon Electrodes." He discussed methods used by the Acheson Co. for determining the density of a carbon electrode and for determining the amount of amorphous carbon in a graphite electrode. A long abstract of this interesting paper is given on another page of this issue. The paper was discussed by Messrs. Hart, Hutton and Keith.

Professor Hart suggested the use of persulphates for distinguishing between amorphous carbon and graphite in a similar way as they are now used in the determination of manganese in steel. Mr. Hutton called attention to the different behavior of graphite made in different ways, principally by dissolving the carbon in different metals. This was confirmed by Mr. Fitzgerald, who said that there are as many kinds of graphites as there are of amorphous carbon, and that the subject is really a very vast one.

The next paper was read by Dr. J. W. RICHARDS, on "The Efficiency of Electric Furnace Operations." A longer abstract of this paper is given on another page of this issue. The paper was discussed by Messrs. Hering, Bancroft, Hart, Whitney and Haber. Mr. Hering pointed out that the determination of the efficiency requires the knowledge of the theoretical amount of energy necessary for a given process, and that this theoretical amount is often not definitely known. For instance, in the case of calcium carbide, the theoretical values given by different authors vary greatly. In reply to a question on the possibility of reducing the radiation loss by getting up the walls of the furnace in such a way as to leave small air chambers throughout the wall, Professor Richards replied that he thinks it is better to relatively reduce the radiation loss by increasing the size of the furnace and working at a faster rate.

The next paper on the programme, by P. G. SALOM, on some improvements of the process of electrical lead reduction, was not read, on account of pending patents. It was promised for the next meeting. The theoretical problems involved in this process were, however, discussed at length in an interesting paper presented by A. J. WEIGHTMAN, on "Cathodic Reduction." A longer abstract of this paper is given on another page of this issue. It elicited an animated discussion, in which Messrs. Reed, Keith, Hering, Rodman, Haber, Hutton and Blackmore participated. Mr. Reed did not think that it is necessary to have recourse to Caspari's theory of the overvoltage. He claimed that Weightman's results could be explained by the simple rule that where there is a mixture of cathodes (i. e., where the cathode contains two materials capable of reduction) the current divides itself between the two in a proportion depending upon the accessibility of these two cathodes. On the other hand, Professor Haber held that such considerations do not overcome the difficulty, that hydrogen will not develop on the cathode without overvoltage. He suggested that there might be intermediate steps between the formation of gases from ions, such as solution, adsorption, the formation of an alloy, etc.

The last paper of this session was read by Dr. LOUIS KAHLENBERG, on "Differences of Potential between Metallic Cadmium and Solutions of Cadmium Iodide in Various Solvents." Cadmium iodide was used as the solvent, because it is readily obtained in a pure anhydrous form, and is soluble in a goodly number of solvents, the resulting solutions often being fair electrolytes. As solvents, mostly nitrites and amines were used. The concentration used was 0.1 gram equivalent per liter, or concentrated solutions were used in case the salt was not sufficiently soluble. The difference of potential between metallic cadmium and the solutions of cadmium iodide was measured against Ostwald's normal electrode (a normal solution of potassium chloride in contact with an excess of mercurous chloride and metallic mercury). The cadmium was always the negative pole. The e. m. f. of the normal electrode was assumed to be — 0.56 volts, and the e. m. f. at the junction of the two liquids was neglected. The principal result of his measurements may be stated as follows: The difference of potential between a metal and a solution is

determined by the chemical affinity between the metal and the solution. Differences of potential between a metal and a solution of the same strength in solvents that are chemically analogous are of the same general order of magnitude, though they are by no means identical.

Before this session was closed, DR. C. A. DOREMUS called attention to the International Congress for Applied Chemistry, to be held next June, in Berlin, under the auspices of the German Government. Dr. Wiley, of the United States Department of Agriculture, forms a committee of organization for America. An important section of the congress will be the electrochemical section. He moved to request the Board of Managers to take action regarding the appointment of delegates to this congress. The motion was carried.

During the afternoon the visits to the various plants, mentioned above, took place.

#### TUESDAY'S SESSION.

The first paper of this session was by MARCUS RUTHENBERG, on "Developments in the Electrometallurgy of Iron and Steel." In the absence of the author it was read by Dr. E. Hart. A longer abstract of this paper will be published in our next issue. It was discussed at length by Messrs. Hart, Keith, Johnson, Hering, Reed, Salom and Richards. Dr. Hart mentioned a process by Blake of electric (not magnetic) concentration, used in an experimental plant of Schwartze, in Denver. The small particles of ore are charged electrostatically. Some of the particles take the charge more rapidly than others and lose it less rapidly. This gives a new principle of separation, the quantity of energy required being quite small. Moreover, it is possible to separate, in this way, particles which cannot be separated very easily by water concentration, because of their fineness. He thought that Mr. Ruthenberg takes too sanguine a view of the possibilities of the electric furnace in iron smelting, as it should not be forgotten that to-day the iron-smelting furnace is absolutely the most economical furnace in existence. Other speakers also expressed the opinion that the electric furnace for iron and steel has the very great handicap of high cost. Dr. Keith referred to Edison's efforts in magnetic separation. Mr. Reed remarked that Edison's problem is a very difficult one, as he starts with an ore which contains on an average about 20 per cent. of iron; the rest is rock, and there is also a large amount of phosphorus. The ore must first be ground to a very fine mesh; then the phosphorus is removed; then follows washing, drying and briquetting before the ore can be concentrated in the magnetic separator. These various processes make the product quite expensive. Mr. Reed believed, however, that magnetic separation is quite economic for certain kinds of ore, which exist in immense quantities, and have only to be ground to a quarter or one-eighth mesh, and then merely have to be run through a magnetic separator, without requiring further treatment. Mr. Salom expressed the opinion that there is not much danger in the immediate future of the electric furnace superseding the blast furnace as a method of manufacturing iron or steel, although the possibilities of it are not to be ignored in the future. He also thinks that, in view of the enormous amounts of high-grade ores that are still in existence, all the attempts at concentration processes will be a failure until the good ores become scarce. It does not pay to operate 5 and 10 per cent. ores when one can get 50 and 60 per cent. ores. Magnetic separation may, however, be economic with ores below 50 per cent., and containing a large amount of phosphorus. It pays to bring them up to over 60 per cent. and get rid of the phosphorus.

The next paper was read by DR. EUGENE A. BYRNES, on "Voltaic Cells with Fused Electrolytes." The author gave the results of a great number of measurements of the e. m. f.'s of voltaic cells of the type generally called a "carbon cell." The electrolyte used throughout was primarily sodium hydroxide, contained in an iron or other vessel and maintained in fusion by a gas furnace. The electrodes were of carbon, especially

graphite, and of various metals. In one set of experiments, both electrodes were introduced into an open vessel containing the molten sodium hydroxide. In the other set of measurements, the molten caustic was divided into separate portions by a porous cup, and various oxidizing agents or depolarizers were supplied to the portion containing the cathode. The porous cup was made by taking two concentric cups of perforated sheet iron, separated by a space of 1 cm., this space being filled with "an oxide" in granular form. Concerning the results of the measurements—which mostly gave e. m. f.'s much smaller than 1 volt—the reader must be referred to the full paper, which will be published in the "Transactions of the Society." Some of his results are in fair agreement with former results of Liebenow and Strasser. In the discussion of the paper Mr. Reed remarked that he believed the e. m. f. of such cells to be mostly thermo-electric. Dr. Byrnes, in his reply, did not deny that there may be a thermo-electric effect, but it is only partial and not the principal effect.

The next paper was read by R. S. HUTTON, of Owens College, Manchester, England, on "The Fusion of Quartz in the Electric Furnace," for the purpose of making quartz fibers and small tubes for scientific purposes. A transparent, glass-like substance is produced, which has an exceedingly small coefficient of expansion and a high melting point. In the first attempts of heating quartz in the electric arc, chemical changes were observed, reduction to silicon and carborundum. If precautions are taken, however, to insure an oxidizing atmosphere around the quartz, it can be easily fused by the arc without any complications. He first experimented with a small open arc, with a magnetically-deflected flame, but this method is not suitable for working at a large scale. He later experimented with a small laboratory electric furnace of the Moissan type, using a direct current of 300 to 500 amperes, at about 50 volts. The method used consists essentially in making a mold and casting the tube in this mold. The mold consists of a graphite block, and is grooved out. As an axis, a small graphite rod, of the diameter of the bore of the tube required, is supported on end pieces. The mold is fed gradually under the arc, the portion immediately underneath becoming very quickly fused, when the carbon is advanced little by little, until the whole mass is fused along its entire length. The mass thus produced always contained a large number of small inclosed air bubbles, which greatly impair its transparency. He also tried the following method: A carbon rod, or carbon of any other shape required, is brought to white heat by passing an electric current through it, the carbon being surrounded by sand or finely-divided quartz crystals. In this way, in almost a moment, the heating is sufficient to cause a powerful agglomeration of the particles of silica in the neighborhood of the heated carbon, and although by the process the material only becomes melted just at the inside, near the carbon, he believes such a method would be useful for forming a tube or other shaped masses which can afterwards be treated. Mr. Hutton's paper was discussed by Messrs. Whitney, Bancroft, Fitzgerald and Doremus.

The next paper was read by PROF. HENRY S. CARHART, on "A Thermo-electric Theory of Concentration Cells." The paper was an extension of the theoretical considerations given in the author's paper published in *ELECTROCHEMICAL INDUSTRY* last month. The author showed how both Nernst's theory and Helmholtz's formula led to the definition of a concentration cell as a device for converting heat into electrical energy. For the understanding of a concentration cell, it is therefore necessary to study the thermo-electric forces at the two electrodes. He has discovered the law that the thermo-electric force increases with the concentration of the solution. According to his theory, the e. m. f. of a concentration cell is represented by the difference of the two thermo-electric forces at the electrodes, and this difference is not zero, because the thermo e. m. f. at the concentrated solution is greater than at the dilute solution. He exhibited very interesting curves, and made an application of his results to the theory of the Daniell



cell. The paper elicited an animated discussion, in which Messrs. Bancroft, Haber, Hering, Kahlenberg, Carveth, Patterson, Weightman, Reed, Richards and Keith participated. Professor Haber claimed that Helmholtz's formula and Van't Hoff's formula, taken together, explain completely anything concerning the theory of a concentration cell. Mr. Weightman had made some experiments with the nickel cell described by Professor Carhart in a former paper. He short-circuited such a cell, and found that he did not get a deposition of nickel at all in the dilute solution, and that although the electrode in the strong solution lost a certain amount of weight, it did not go into the solution as a sulphate.

The next paper was read by CARL HERING, on "An Apparent Electrochemical Paradox." He described a curious experiment which he and Mr. Reed made some years ago, in which water was decomposed in visible quantities at voltages far below the theoretical value (about 1.45 volt), even as low as about 0.3 volt. This seems to contradict the law of the conservation of energy, as these gases in re-combining could generate more than this amount of energy. The experiment consisted in electrolyzing acidulated water in a strong N-shaped glass tube, which was sealed at both ends and provided with a bend containing mercury, which enabled the mechanical pressures to be read off. The results were shown in a curve. The pressures reached about 23 atmospheres, when the tube exploded. The voltage at the terminals, when a constant current passed, diminished rapidly and very decidedly to about 0.3 volt at about 16 atmospheres, and then remained practically constant. Allowing for the loss due to resistance, the actual voltage of decomposition was even much lower, nearly zero. There was visible gasing during the whole test, showing that water was really being decomposed. The increasing pressures also showed this. No researches were made to find the correct explanation of this curious result, the intention of the paper being merely to describe the experiment. A possible explanation was, however, suggested, showing how the results need not be inconsistent with Faraday's law or the law of the conservation of energy. It is based on the assumption that some of the gases liberated at one electrode probably passed mechanically to the opposite electrode, which they could easily do in suspension, as the electrodes were very close together. These were then consumed as depolarizers, and this depolarization lowered the voltage. The paper concludes with a suggestion of an experiment in which water is electrolyzed in a strong sealed vessel which is completely filled, so as to leave no room for the gases. Some curious results may then be expected. Mr. Hering's paper was discussed at great length by Messrs. Rodman, Johnson, Carhart, Reed, Hutton, Burgess, Bancroft, Kahlenberg, Haber and Richards. Some similar experiments were mentioned, and in general the explanation given by Mr. Hering seemed to be accepted by the speakers.

#### WEDNESDAY'S TWO SESSIONS.

The first paper of the morning session was read by PROF. W. E. GOLDSBOROUGH, on "Electrochemistry at the World's Fair, St. Louis, 1904," a longer abstract of which will be published in our next issue. The paper was a strong plea for co-operation of the Society to make the exposition a great success in the electrochemical department. The aim will be to make the people of the country at large familiar with the applications of electrochemistry. Processes will be shown in operation. He urged manufacturers to exhibit model plants which show the principle of the process in working. They may embody only the fundamental and essential points of the process, and may differ in many details from the actual process as worked on an industrial scale, so that no trade secrets are revealed. The address was heartily applauded, and the following resolution, proposed by Carl Hering, and seconded by Messrs. Carhart and Coho, was then unanimously accepted by the Society:

"WHEREAS, The American Electrochemical Society, in convention assembled, recognizes the great international impor-

tance of the Louisiana Purchase Exposition, and feels that it will do much in placing before the people of the world a true picture of our national progress; and,

"WHEREAS, In no branch of our scientific or industrial progress have greater developments taken place recently than in the field of electrochemistry;

"Resolved, That the American Electrochemical Society hears with great satisfaction the announcement that steps are being taken looking to the organization of a fine and comprehensive exhibit in the group of electrochemistry, and offers assurances of hearty good-will and co-operation in the accomplishment of this much-to-be-desired end."

The next paper was read by DR. H. T. BARNES, on "The Theory and Practice of Continuous Flow Calorimetry." The method discussed in this paper has been worked out with great care in the last five or six years. It is useful for actual calorimetric measurements in the laboratory, and to show the relationship between electrical and heat units. It is to be used in connection with the Weston electrical instruments. In principle the method consists in having a flow of liquid continuously heated by an electric current in a fine flow-tube. The liquid is allowed to flow until the temperature conditions have become perfectly steady. The temperatures of the inflow and outflow and the e. m. f. and current are then measured. The method has been elaborated with the greatest accuracy, and is an interesting example of the high accuracy which can be obtained in the experimental methods of modern physics. The author discusses the sources of error, and shows how they are eliminated. To mention only one detail, the heat wire is in the form of a spiral, in order to break up the stream lines in the liquid, which is very important. The paper was discussed by Messrs. Kahlenberg, Cowles, Hutton, Potter, Whitney, Carhart and Patterson. Mr. Potter suggested a somewhat different mechanical construction. Professor Carhart pointed out the great exactness of modern methods of measurements, indicated by the fact that Barnes' measurements lead to results which agree exactly with Carhart's determination of the e. m. f. of the Clark cell.

The next paper was read by WOOLSEY McA. JOHNSON, on "The Electrolytic Dissolution of Soluble Metallic Anodes." A longer abstract of the paper, which is an interesting discussion of several points of the theory of electrolytic refining processes, is given on another page of this issue. The paper was discussed by Messrs. Bancroft, Keith and Reed. Dr. Bancroft corrected a mistake in an assumption made by the author, and Dr. Keith claimed that the alleged difficulties in processes of electrolytic refining do not exist in reality.

ARVID REUTERDAHL then read a paper on "The Electronic Hypothesis and its Applications." This paper was a continuation of the discussions started by the author in a paper read before the Society at the first meeting, in Philadelphia. Like the former paper, his present paper is rich in sarcastic and amusing remarks on the very artificial assumptions often made by theoretical physicists, in order to save a theory; for instance, the various assumptions concerning the properties of the ether, etc. The author first discusses the phenomena which have led to the hypothesis of electrons. One point to which he called strongly the attention of the hearers was that an electron is assumed to represent not only an electric charge or quantity, but also to have a mass. He claimed that the latter point is often forgotten by theoretical physicists in applying the hypothesis of electrons. In the second part of his paper he spoke at length of the law of gravitation, and attempted to prove that it is too one-sided, because it speaks only of attraction. He wants to substitute for it the electric law of inverse squares, and claims that all difficulties then disappear. In the discussion which followed Dr. Whitney made some remarks on experimental researches begun by him with the intention to detect positive electrons. Professor Carhart entered a strong protest against at least one of the critical remarks of Mr. Reuterdahl on difficulties of the molecular theory, and said that these difficulties had long ago been satisfactorily explained

by Clansius. Mr. Reuterdaahl, in a brief reply, insisted on the position he had taken in his paper.

HUGH RODMAN then read a paper on "Storage Battery Invention," which is essentially a critical comparison of the lead cell and the new Edison cell. A longer abstract is given on another page of this issue. The paper was discussed by Mr. Reed, Dr. Keith and others. Dr. Keith expressed the opinion that the inherent difficulties which the Edison is claimed to have are more alleged than real. Mr. Reed said that if certain reports of the daily press concerning actual runs of automobiles with Edison batteries are correct, then the problem has been completely solved by Edison. It appeared, however, that most of the speakers were somewhat skeptical concerning the exactness of those newspaper reports.

In the afternoon session the first speaker was DR. F. HABER, professor of the Institute of Technology, in Karlsruhe, Germany. As the official delegate of the German Bunsen Society, he brought to the American Electrochemical Society the good wishes and greetings of the German sister society. He then read his paper on "The Phenomenon of the Formation of Metallic Dust from Cathodes." He has studied for several years this phenomenon, which seems singular at first sight, but is of greater general importance. He showed two experiments in which he sent the current from 20 storage batteries through a cell containing a 20 per cent. solution of potassium hydroxide. In both experiments an iron nail was the anode, while the cathode was a nail of lead in the one case and a nail of tin in the other. When the current is closed, a black cloud of dust goes off from the cathode, and is distributed in suspended form throughout the solution, so that it finally looks like ink. The cloud consists of dust of the material of the cathode. This phenomenon takes place when the current density at the cathode is sufficiently great. The explanation of the phenomenon is as follows: The cation of the solution forms an alloy with the metal of the cathode. This alloy contains a relatively high percentage of the alkali metal, if the current density at the cathode is high enough. It can be shown, however, that such an alloy cannot exist in contact with water or a caustic alkali solution. If such an alloy is prepared by a purely chemical method, and is brought in contact with water, exactly the same formation of dust occurs. Hence, in his experiments, the electrochemical action consists in bringing the alkali metal cations to the cathode; they form an alloy with the metal of the cathode, and, by secondary chemical action, this alloy is decomposed and the formation of dust takes place. When the cathodic current density is high, rich alloys are formed, and the formation of dust takes place. When the cathodic current density is low, the alloys will be poorer; there is no formation of metallic dust, but the surface of the cathode shows signs of having been attacked. Similar experiments have been made with lead and bismuth cathodes in acid solutions. An alloy of hydrogen is formed in this case, which is rapidly decomposed in contact with water, and gives off hydrogen.

The paper was discussed at length by Messrs. Keith, Bancroft, Carhart, Kahlenberg, Reed and Richards. Dr. Bancroft suggested that there might be a connection between this phenomenon and the fact that certain cathodes have a greater reducing power than others. Dr. Haber confirmed this, but stated that it is difficult to say exactly what the relation is between the alloy formed and the change of the reducing power. Mr. Reed had previously described the same phenomenon. Professor Carhart described the following method of producing a very firmly-adhering layer of platinum black on platinum: He decomposes zinc sulphate with a very small current, say 0.1 ampère and 50 square centimeters surface of platinum cathode, for five or six hours. Afterwards the circuit is broken and the platinum plate is left in the solution; in some hours it turns black. The explanation is that an alloy of zinc and platinum has been formed, which cannot exist on account of the free acid present in the solution, and is then

decomposed. Dr. Kahlenberg remarked that well-adhesive electroplating deposits can only be obtained if first an alloy is formed.

The next paper was read by ALFRED H. COWLES, on "Certain Electrical Units," suggested in order to co-ordinate mass quantity with electricity quantity, and for use in tracing energy in its transformations accompanying chemical reactions. The paper was interesting, as it showed some very simple numerical relations which enable the author to suggest a new system of units for practical purposes. The author goes even further; he endeavors to prove that those simple numerical relations are not merely accidental, and he tries to find their deeper unknown significance. This part of the paper is strikingly original, and shows the characteristic qualities of the pioneer who goes ahead and asks: "Why is it?" where others would simply speak of an accidental coincidence, and would not care to look for deeper unknown causes. True, Mr. Cowles has not yet found the last connecting link which would prove that there is really a deeper significance in the relation found by him, yet, as he is convinced that it exists, he is right in speculating to find it, for "if you do not speculate you can never strike the truth."

The author considers units as "measuring tools for use in reasoning," and points out that for special subjects, like electrolysis, they should be of such convenient dimensions as not to be cumbersome. He has found that, as a coincidence, 500 ampères in one day (12,000 amp. hours) decompose practically (within 1 per cent.) a pound molecule of any univalent compound. The convenience of this close relationship suggests the idea of making it the basis of a unit, the *pound Col*. While this unit is of the same nature as the coulomb, it has merged in it the day as a larger unit of time. He then discusses the proportionality which exists, according to Faraday's law, in electrolysis between the quantity of electricity and the mass, if the latter is measured by gram equivalents. In the light of the relationships which are known to exist between conductivity in electrolysis, osmotic pressure, vapor tension and the raising and lowering of melting and boiling points, he thinks it would be of value to have a set of units of electrical quantities related to or dependent upon a unit quantity, by weight and volume, of hydrogen, which in turn is related to the gram and the c. c. of water by a constant figure. He has found that 100 ampères in one day free 1 c. c. of hydrogen, and he says that when figuring out this from the most reliable experimental data one finds this relation to be exact. He therefore suggests to make this a new unit, and, as the weight is a kilocrit, he calls it a kilocrit *Col*. He suggests a whole system of new units. For instance, he proposes to create a table of "apparent relative atomic capacities for electricity," similar to the table of atomic weights. From such a table thermal reactions or energy transformations would be read with the same ease that we now read and trace the shifting of mass in chemical reactions. It is this relation—that 100 ampères in one day free 1 c. c. of hydrogen—which the author discusses in the second part of his paper, endeavoring to find a physical reason for this relation. It is evident that this must be an extremely complicated matter, as here very different units of physical science are interlinked. Mr. Cowles goes on to put together the relations existing between the units which enter into the problem, but, as mentioned before, he is unable to find the last connecting link. Concerning the details, we must refer the reader to the full paper, which will be printed in the "Transactions of the Society."

The paper was discussed by Messrs. Whitney, Bancroft, Hering, Reed, Richards and Keith, most of whom considered the relations pointed out by Mr. Cowles to be very interesting, but accidental.

The last paper of this session was read by EDWARD R. TAYLOR, on "A Closed and Continuous Working Electric Furnace." The author points out that continuity of operation is very important, and almost an absolute necessity for most

chemical manufacturers. Movable electrodes in a closed electric furnace present serious difficulties in this regard. He early thought of using pieces of conductive material that can settle down upon each other from above, and properly arrange themselves and feed down by gravity. He decided to carry the current into the furnace by the use of a stationary conductor of moderate size, and to separately arrange the moving portions inside of the furnace itself. In his former paper, read at the Philadelphia meeting of the Society, he presented a plan of prolonging the life of the electrodes by regularly feeding upon them and at their ends, by gravity, broken conductive material. In his present paper he describes what is practically a continually self-renewing electrode in a closed furnace, the broken and moving portions in their continual descent themselves constituting the electrodes. New material constantly descends and takes the place of that exhausted at the ends of points of wear. The conduits through which these broken pieces are fed are suitably connected by an insulated conductor through the shell of the furnace to the source of electricity. Suitable hoppers are made above the conduits and outside of the furnace, through which the broken conductive material can be fed into, and ultimately through, the several conduits, at the bottom of which the broken fragments are free to arrange themselves by gravity, so that the weakest part of the circuit will be determined where the pieces come together at the bottom of the furnace. As fast as the lower ones are exhausted, others feed down from above and take their place. A second requisite for an electric furnace that shall be capable of continuous and prolonged use, without stopping to clean out, is that either a non-volatile product or residue may be removed from the furnace, either continuously or at intervals, in a fused or molten state. Provision is made to increase or reduce the resistance of the furnace at will by feeding conductive or non-conductive material through openings provided in front of the conduits down upon the working ends of the electrodes, so that comparatively quick changes can be made in the resistance of the working furnace. Mr. Taylor stated that, with less nerve on his part and less actual risk of failure than it required to build the furnaces he operates at present, he could now construct a continuous electric furnace that would dwarf the largest blast furnace in existence. (An illustrated description of the latest form of his furnace is given on another page of this issue. See also the notes on his latest patent in the Analysis of Current Electrochemical Patents.)

#### THURSDAY'S SESSION.

The first paper of this session was on "Pumps and Other Accessories in Electrochemical Processes," by DAVID H. BROWNE. In the absence of the author, it was read by W. McA. Johnson. A longer abstract of this paper is given on another page of this issue. It was discussed by Messrs. Keith, Hering, Johnson and Richards. Dr. Keith and Mr. Hering pointed out the advantages of the compressed-air lift system for such solutions, which is of special value when the aeration and resulting oxidation of the solution is desirable. Mr. Johnson said that steam injectors are suitable in some cases.

The next paper was on "Electrochemical Polarization," the author being PROF. J. W. LANGLEY. In his absence, the paper was read by H. N. Potter. The author mentions Reed's definition of electrochemical polarization as a progressive change in the composition and e. m. f. of an electrochemical system necessitated by the progressive exhaustion of one or more of the electrochemical reagents. He takes exception to the importance given to the idea of progression as an essential part of the phenomenon. The phenomenon of polarization is generally considered to occur instantaneously upon the passage of a current through an electrolyte, and it usually reaches a limiting value very soon. The solution begins to be altered at the face of each electrode instantaneously, this change being always of such a character as to make the cell act as a primary battery, with its e. m. f. opposed to that of the e. m. f. which is

driving the electrolyzing current. This is true even in the case of so-called non-polarizable electrodes; for instance, when a current is passed through a cell containing two zinc plates in zinc sulphates. He describes the following method for measuring the counter e. m. f. of polarization. A current is passed through an electrolytic cell, and by means of a quick-acting commutator the feeding current is interrupted, and then, almost instantaneously, the electrodes are connected in series with a condenser. The circuit between the electrodes and the condenser is then broken, and the latter discharged through a ballistic galvanometer. The commutator is arranged to do all this by a single movement of the switch, and in a very brief interval of time. The observer thus obtains the voltage of the charging current, and about one-tenth of a second later the counter e. m. f., caused by the chemical products corresponding to polarization. He gives the results of a series of experiments in form of diagrams, in which the abscissas represent the applied volts of the electrolyzing current and the ordinates the polarization voltage. The experiments were made with various solutions, and also with fused salts. The general character of the curves is that, first, the polarization voltage rises with an increase of the charging voltage as a nearly linear function, later less rapidly, and finally reaches a constant value. This constant value apparently indicates that then the entire stratum on the face of the electrodes, and of the thickness of at least the radius of molecular attraction, is occupied solely by the chemical substance at that face, e. g., for pure water a solution of oxygen at the anode and a solution of hydrogen at the cathode. Prior to this time the film is only partly composed of these substances, some of the original liquid still being present. The author is opposed to considering ohmic resistance as forming any part of electrochemical polarization. The method of discharge seems to be the only one, but, as the polarization should be regarded as the instantaneous value of the counter e. m. f. existing during the passage of the electrolyzing current, the above method, by discharge, will always give too low results, because there is a certain, although very small, time interval between cutting off the electrolyzing current and cutting in the condenser.

The paper was discussed by Messrs. Hering, Reed, Cowles, Potter and Richards, the principal point of discussion being the definition of polarization. Mr. Potter criticised the experimental method, as the existence of an indefinite time element introduces a doubt with respect to the experimental results.

The last paper of the session was on "Some Phenomena of Electrolytic Conduction," the author being C. J. REED. As Mr. Reed, the very active secretary of the Society, was compelled to leave for home on that very morning, on account of sickness, his paper was read by Carl Hering. The author starts with some general remarks on oxidation and reduction as representing the true electrochemical action. He compares, with the aid of diagrams, two different views which are held on the details of the mechanism of the migration of the ions. He calls the one that of Faraday, and the other that of the dissociation theory. He then describes experiments which he has made, the principal one being as follows: A receptacle is divided into various compartments, filled with electrolytes, the end compartments containing the electrodes, so that all compartments are in series. For the sake of simplicity (although Mr. Reed's apparatus is more complicated), we may assume that there are three compartments in series, separated from one another by diaphragms. In the middle and cathode compartments we have a solution of sulphuric acid; in the anode compartment we have copper sulphate. The density and composition of the copper sulphate solution in the anode compartment are artificially held constant during the test. When a current is sent through this system it is easy to calculate what should happen if the whole process consisted in a traveling of H, Cu and SO<sub>4</sub> ions with their respective mobilities, which have been determined by previous investigators. As the H ions have a much



greater and the Cu ions a smaller velocity than the  $\text{SO}_4$  ions, a simple calculation shows that one should expect that the weight of the solution of the middle compartment and the contents of  $\text{SO}_4$  in the same should decrease. This was, however, not the case in Mr. Reed's experiments. Just the opposite took place, and the volume of this compartment continually increased.

Although Mr. Reed had simply stated the fact and its disagreement with the simple calculation mentioned above, most of the speakers who discussed the paper appeared to regard it as intended to overthrow the electrolytic dissociation theory, and endeavored to show that the results of the experiments do not prove the incorrectness of this theory. Messrs. Hering, Potter, Cowles, Johnson and Richards participated in the discussion. Mr. Hering pointed out that Mr. Reed's experiment did really not represent a test of the dissociation theory, but was a sort of determination of the ionic velocities. In such a determination the nature of the porous diaphragms is of great importance. It was also pointed out that Mr. Reed did not take into account the phenomenon of electric endosmosis, which is known to exist. Mr. Potter expressed the opinion that Mr. Reed's apparatus was of such a construction as to necessarily introduce sources of error. He thought that heat affects may have been the cause of the increase of volume. Professor Richards thought that the use of the word "dissociation" for ions in solution is unfortunate, and explained the difference between chemical dissociation and electrolytic ionisation by means of mechanical analogies. Mr. Reed will certainly reply in the *Transactions* in a communicated discussion.

At the close of the session, Mr. Hering moved resolutions of thanks, for courtesies received, to the Local Entertainment Committee, the Ladies' Committee, the Niagara Power Co., the Niagara Falls Hydraulic and Mfg. Co., the National Food Co., the International Acheson Graphite Co., the Carborundum Co., the Electrical Lead Reduction Co. and the Atmospheric Products Co. The meeting then adjourned.

#### PUMPS AND OTHER MECHANICAL ACCESSORIES IN ELECTROCHEMICAL PLANTS.

In an American Electrochemical Society paper, which is valuable on account of the large amount of technical information given in it concerning details, DAVID H. BROWNE, Cleveland, Ohio, points out that the successful conduct of any electrochemical process depends to a large extent upon the practical solution of the mechanical problems involved. He gives in a humorous style a very interesting account of his struggles with pumps, heaters and other mechanical accessories, as he had to handle for several years a hot concentrated solution of chloride of copper and nickel, with some free chlorine, some hydrochloric acid, and a lot of impurities, such as sand, graphite, copper sulphide, metallic particles, chips of wood, etc.

First, he records a long series of unsuccessful trials with various arrangements, all of which had to be finally discarded; but when this paper will be printed in full, it will be interesting reading, because the author not only describes the unsuccessful arrangements, but also says why they were unsuccessful. When the problem of evaporating and concentrating large amounts of solution became important, they devised a concrete evaporating pan of the following construction. The base of this evaporator was built of brick, the top course being laid in cement, and a cement coat with a slight slope to the front being laid over the top of the brickwork. On this platform was built a shallow concrete pan with sloping sides; a wall down the middle divided this into two equal compartments, which communicated with an opening in the party-wall; they were covered by heavy tiles. While the solution is flowing through, any crystals settling out are raked off the bottom up the sloping sides to a trough. A chimney assists in drawing a current of hot air from the brick oven heated by an oil

burner. While this apparatus was successful to some extent, there were two sources of trouble: the coating of the solutions with a floating layer of crystals, and the cracking of the concrete due to alternate heating and cooling. The trouble due to the coating of salts covering the surface of the liquid suggested to them an idea of an evaporator in which a very thin film of solution is continually exposed to a stream of hot air.

The apparatus consists of an iron shell, closed at the upper end by a circular lip, and at the lower end by a similar, but more shallow lip. This shell is lined with bricks and cement and is rotated by a peripheral driving gear. An oil burner in a brick furnace to one side produces a current of hot air, which entering the evaporator by a sleeve, passes along the top of the arch, meeting there a film of liquid which is continuously dragged up from the pool. The solution flows in continually and flows out continuously over the lip through a ring opening around the air sleeve. Any crystals separating are carried in suspension into a tank where they settle out, while the solution passes on towards the pump pit. At first they used a fan to draw the air through, but they found out that better results were obtained by checking the air flow to such an extent that the exit gases were nearly saturated with moisture. He recommends this apparatus as very satisfactory; for further details and illustrations we must refer the reader to the full paper.

When a pump is made of parts—generally three main parts—he recommends to assemble the three main parts in a box, laying the pieces close together without gaskets between. Around these pieces granite concrete is rammed, and the block allowed three or four days to harden before removing the box. To provide for the bolts which hold down the valve checks and the piston gland, short pieces of iron pipe may be laid in the box before the concrete is rammed in, or still better, T-shaped slots may be provided in the concrete by suitable wooden forms nailed against the side of the mould. A three-piece pump so mounted is practically one solid block of stone. It requires no fastening, can be laid on the floor anywhere, and is very readily lined up beneath a driving shaft. As a gasket for this style of pump he has found common felt well soaked in P. & B. paint to be a good substitute for hard rubber.

Recently, they also used pumps made in one piece. Such a pump is very easily mounted in a concrete block. One end is provided with a skeleton ball check, which acts both as a check and discharge opening. The exit pipe is coupled to this by a flat flange and hard rubber nipple. To hold down the check and the piston gland they use a heavy cast-iron plate with two claws on each side, against which the bolt heads or washers can be drawn up. This makes a very compact form of pump mounting.

As a suction pipe he uses either a section of a wood pump log drawn tight against the lower part of the pump body, or a hard rubber flange and nipple coupled to a length of flexible hose of sufficient wall thickness to withstand the collapsing strain. For discharge pipe he uses almost exclusively a permanent concrete main.

#### ELECTROCHEMICAL LECTURES.

**Franklin Institute.**—Among the papers announced on the preliminary programme of the sections of the Franklin Institute of Philadelphia we note the following: Dr. J. W. Richards, Bethlehem, and C. M. Hall, Niagara Falls, "The Electrothermic Production of Aluminum from Bauxite;" Dr. Harry F. Keller, Philadelphia, "The Synthetic Production of Perfumes and Flavoring Matter;" W. E. Ridenour, Philadelphia, "The Influence of Bleaching Agents on the Tensile Strength of Textile Fibres;" Miss A. L. Turner, Philadelphia, "The Electrolysis of Di-sodium Phosphate;" A. C. Johnston, Philadelphia, "Ore Handling;" Dr. H. C. Jones, Baltimore, "What Physical Chemistry Has Done for Chemistry."

## ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

BY GEORGE P. SCHOLL.

## ELECTRIC FURNACES AND FURNACE PRODUCTS.

*Reduction of Metals from their Ores, etc., in Electrically-heated Furnaces.* Ramon Chavarria Contardo, Sèvres, France. Patent No. 706,651, July 29, 1902.

This invention, according to the specification, "relates to a process and apparatus for the production of metals directly from their ores, and more particularly to a process for producing cast iron or steel of any desired degree of hardness directly from iron ore without the use of solid fuel." For this purpose the inventor, who is a doctor of laws, a citizen of the Republic of Chile and residing in Sèvres, France, constructs a furnace, very much like a blast furnace in cross-section, in which he proposes to furnish the heat necessary for the melting of the charge by means of the electric arc. This heat is to act only by convection and radiation, as the material itself does not come into contact with the arc, the electrodes being carefully protected by shields. To accomplish the reduction of the heated ores he proposes to introduce into the bottom of the furnace, below the electrodes, a current of dry hydrogen or carbon monoxide, obtained from a suitable generator. He also states that in the particular case where the furnace is to be used for the production of cast iron or steel, it is necessary that carbon combine with the iron and that this may be attained by introducing into the reducing-gas current an easily proportionable quantity of a hydrocarbon in the form of gas or vapor, by which procedure it is claimed that the exact quantity of carbon required can be combined with the iron. From the above description it can already be inferred that the process in question appears to be one of the many which have been proposed for the utilization of the electric current in the metallurgy of iron, but which have never been heard of in practice. Besides using a temperature much beyond anything required in the iron business, the process presents metallurgical and practical difficulties which are almost or quite unsurmountable. There is certainly no need of apprehension on the part of stockholders of iron and steel companies, as long as such complicated and expensive processes are proposed to take the place of the simple and well-developed processes used at present in the metallurgy of iron. The problem seems to be an attractive one to inventors, especially those who are not metallurgists by profession, although there is probably less chance for electricity to be applied in the manufacture of iron and steel than in that of any of the other metals.

*Electric Furnaces.* Arthur Parker, Chorley, England. Patent No. 706,099, August 5, 1902.

The inventor describes a new form of carbide furnace, designed, according to him, to secure a more complete, perfect and continuous fusion of the raw material. The furnace is a crucible furnace, lined perfectly with carbon, and so arranged that it can be slowly rotated around its vertical axis. The carbon electrode is as usually arranged in such a manner that it can be moved upwards as the melted charge fills the crucible. The main characteristic of the furnace seems to consist in the shape of the carbon electrode employed, which is described as being oblong in cross-section, either rectangular or oval. As the furnace is rotated, each part of the charge comes successively within the range of the electric arc, over and over again. The inventor lays special stress on the fact that the arc is not struck between the electrode and the crucible through the material, but between the electrode and the melted carbide, and that, therefore, the carbon electrode does not come into contact with the material throughout the whole operation. The material to be fused is delivered into the crucible in a thin stream on both sides of the oblong car-

bon electrode through hoppers and tubes composed of an insulating material, and it is intended to have it fall into or through the arc and thus become fused before reaching the bottom of the crucible.

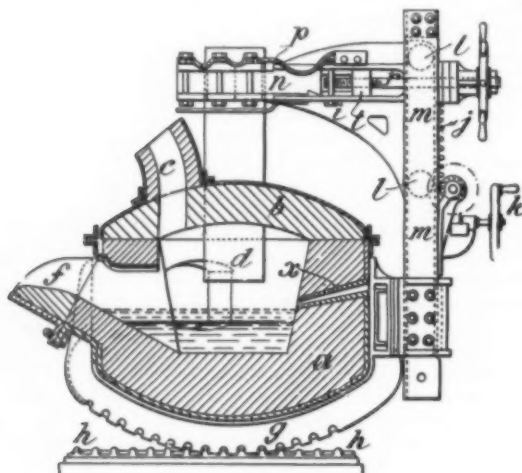
*Electric Furnace.* Edward R. Taylor, Penn Yan, New York. Patent No. 706,128, August 5, 1902.

This furnace embodies various improvements on the inventor's previous furnace, and is to be used primarily for the production of carbon bisulphide, though according to the specification it may be used for other reductions and reactions. Mr. Taylor has had an experience of many years in the manufacture of carbon bisulphide, and deserves great credit for the successful application of electricity in a case where the existing methods were of a most unsatisfactory character. The furnace described in the present patent is used by him on a large scale at Penn Yan, New York. The construction shows a central shaft, through which the charcoal or coke is delivered into a larger working chamber. Concentric to this shaft is arranged a circular space for the feeding in of the sulphur, while several more concentric passages, serving the same purpose, are arranged around the working chamber. The object of this construction is to utilize the heat generated in the working chamber also for the heating and melting of the sulphur, which is delivered by the various passages at different levels in the working chamber. By this means the sulphur is brought into contact with the carbon at a number of places, and the best possible conditions for the reaction are realized. The current is introduced into the furnace by four electrodes, 90° apart, which are constructed in the form of a metallic trough, lined with carbon bricks on three sides and covered with a non-conducting cover on the side towards the interior of the furnace, which arrangement prevents the current from passing directly from one electrode to the other in the upper part of the furnace. These electrode troughs serve at the same time as passageways for the granular conductive material, which is fed into them continuously, and which, after leaving the electrodes, spreads itself out on the bottom of the working chamber and is there heated by the current to the proper temperature. For the protection of these passageways and the regulation and control of the operation of the furnace there are arranged passages running above and parallel to them, by which either conductive or non-conductive material can be introduced into the working chamber and can thus be brought right in front of any or all of the electrodes. The specification is one which will recommend itself to any practical man for the clear statements it contains, which are all to the point and bear witness that the apparatus it describes is a product evolved from actual practical conditions. It shows in this respect a marked contrast to many others, which are unhappily too full of glittering generalities in which the respective inventors allowed their fancy to run riot.

*Oscillating Electric Furnace.* Paul L. Héroult, La Praz, France, assignor to Société Electro-Metallurgique Française. Patent No. 707,776, August 26, 1902.

Héroult, the well-known electro-metallurgist and inventor of the Héroult aluminum furnace, describes in this specification the construction of an oscillating electric furnace, which is to be used among other purposes for the manufacture of steel. As shown in the adjoining diagram, the furnace consists of a crucible *a*, provided with a cover *b*, a small chimney *c*, and a spout for running off the metal on tilting the furnace. The bottom of the furnace is arched and cogs on rails *g* engaging with cogs on rails *h* are arranged for effecting the tilting. The carbon electrodes *d*, surrounded by a collar *n* of sheet

metal, which incloses copper wedges serving to convey the current from the cables *p* to the electrodes, are carried by arms *i* projecting from sliding uprights *j*. The uprights *j* are guided by rollers *l* in a standard *m* of trough-shaped section, and can be worked by a worm and hand wheel *k*. A screw spindle *r* and nut *t*, turned by a hand wheel, provides for the tightening and loosening of the collar *u*. In order to use the



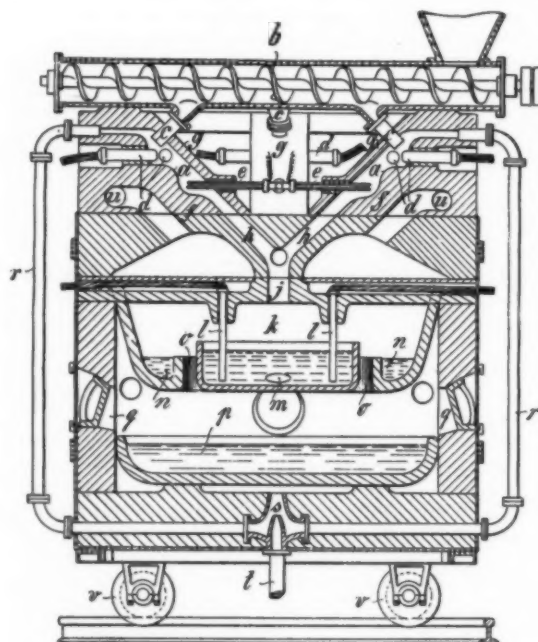
HEROULT FURNACE.

furnace for bessemerizing, a wind chest is arranged at the back of the furnace, from which tuyeres *x* lead into the working chamber. The tuyeres open ordinarily above the level of the bath, but are submerged when the furnace is tilted back in order to carry out the Bessemer process. Though anything coming from Héroult is entitled to serious consideration, it seems that the use of electric furnace in a process which has been brought to such perfection in the working and handling of enormous outputs as bessemerizing has been is an undertaking which will have to contend with many difficulties. It is proposed to use a pig iron, which, as the specification says, "need not contain either phosphorus or silicon," which probably means pig iron low in phosphorus and silicon, as it would be impossible to find a pig iron in the market which does not contain either of these elements. Such pig iron can be used, as it is not necessary in the electric furnace to depend on the oxidation of the silicon in the acid converter or the phosphorus in the basic converter, in order to furnish the necessary heat for the process, which heat is, in this case, supplied by electricity. Pig iron of this kind could, of course, be obtained at a lower price than that used ordinarily in bessemerizing, but this difference would hardly be sufficient to make up for the increase in cost due to the use of electricity. The last judgment in this case will have to be pronounced before the tribunal of practice.

*Electric Glass Furnace.* August Voelker, Cologne, Germany. Patent No. 706,283, August 5, 1902.

Within the last few years several furnace constructions have been patented in different countries, having for their object the utilization of the electric current in the manufacture of glass. The name of the inventor of the furnace under consideration has already appeared in the patent literature in this connection, and the furnace is evidently an improvement on his earlier constructions. The apparatus as shown in cross-section by the adjoining figure, shows a worm conveyor *b*, by which the materials for forming the glass are delivered to four tubes *c*, which lead into inclined radial passages *h* over what the inventor calls the "hearth" *a*. These passages are formed in four refractory blocks *f* and are covered by slabs *g*. There the material is melted by the heat of arcs between the electrodes *d* and by arcs of so-called jablochkoff candles *e*. The

material flows down through the passage *j* into the refining vessel *k*, where the melt is kept fluid by the introduction of another alternating or direct current by means of the electrodes *l*. Here the principle of resistance heating is employed. From *k* the melt flows by openings *m* into the circular trough *n*, whence it overflows by the passages *o* into the lower vessel *p*, where it is worked by tools through the working doors *q*. The vessel *p* is heated by the burning under it of the combustible gases which are evolved in the passages *h*, and are conducted under it by the pipes *r*. The burning is effected by a suitable burner *s* provided with an air-pipe *t*. The apparatus is mounted on wheels *v*. *U*, *u* are channels through which such incombustible gases as are evolved pass off.



VOELKER GLASS FURNACE.

The furnace under consideration removes one objection which has been urged against several other constructions, namely, that no provision was made for a thorough liquation of the glass after melting, which is just as important for getting a good product as the melting itself. This, as it appears, has been amply considered by the inventor. There may be a question whether the use of a separate electric current for keeping the melt liquid will pay in practice; in all cases it seems that a direct current would be objectionable if the inventor should have intended to avoid all danger of possible electrolytic effects. It is also difficult to see how the serious objection arising from the contamination of the melt by carbon dust or carbon particles falling down from the electrodes can be overcome in a satisfactory manner.

*Manufacture of Glass by Means of Electricity.* Yegor Broom, Cologne, Germany. Patent No. 708,309, September 2, 1902.

The present furnace is designed, according to the inventor, to overcome the difficulty which is encountered in previous constructions in that the mixture became agglomerated by partial fusion before it reached the electrodes. In consequence of this it had to be pushed forward, thus arriving at the electrodes intermittently, and not only subjecting them to variable strains, but causing much carbon dust to fall into the glass melt and contaminate it. The inventor proposes to overcome these difficulties by using the mixture in the shape of compressed balls, etc., or of a continuous moving rod. He



arranges a mixing apparatus where he mixes the raw material with a suitable binding material, then it is passed through one pair of rollers where it is compressed and a second pair of heated rollers where it is dried. From there the material passes in a continuous-moving strip between or beneath the electrodes of the furnace, where it is melted by the heat of the electric arc. It would seem from this construction that there still exists an opportunity in this apparatus for the melt to become contaminated by particles falling into it from the electrodes. The construction is open to objection for the reason mentioned above, namely, that no provision apparently is made for the liquation of the glass melt, unless it is intended to perform that process in another apparatus heated by ordinary means. The patent is assigned to the Gesellschaft zur Verwertung der Patente für Glaserzeugung auf elektrischen Wege, Becker & Co., Cologne, Germany, who own several other electric glass processes.

#### APPARATUS AND PROCESSES FOR THE ELECTROLYTIC PRODUCTION OF METALS AND COMPOUNDS.

*Process of Manufacturing Manure from Apatite or Similar Mineral Phosphate.* Johan Gustav Wiborgh and Wilhelm Palmaer, Stockholm, Sweden. Patent No. 707,886, August 26, 1902.

The process as described aims at the formation of an easily-soluble phosphate from apatite or other hard soluble mineral phosphates by electrolysis. For this purpose the inventors use as electrolyte a salt which, on electrolysis, furnishes at the anode an acid capable of forming a soluble salt with lime and at the cathode a basic hydrate. As electrolyte they prefer alkaline or ammoniacal salts which contain, for instance, nitric acid, chloric acid or perchloric acid. The mineral phosphate is placed "in a suitable manner" near the anode and the acid liberated there is supposed to dissolve it. When this solution comes into contact with the cathode liquid, where the alkaline hydrate has been formed, the dissolved phosphate of calcium is again precipitated, but this time in another form, as a white flocculent precipitate which is easily soluble in citric acid. It is said to be advantageous to use a porous diaphragm, so as to prevent the precipitate from going over towards the anode and being redissolved. It is claimed that the electrolyte remains nearly unaltered, but as that is usually claimed by all inventors and so rarely found true after a process is introduced into practice, and as no reactions are given to support that assertion, the statement will have to be verified by actual demonstration. That complex salts like the chlorates or perchlorates should be so easily reformed is somewhat hard to believe. If the salts should not be reformed, then the use of high-priced electrolytes for the manufacture of a cheap product will naturally be inadmissible. The question of apparatus is, of course, not considered in this spirit, which is a process patent only, but it would be interesting to know in what manner the inventors have succeeded in overcoming the difficulties about placing the material "in a suitable manner" near the anode, so that the anion will act on it. This alone has been the stumbling block of a good many processes already. It seems also that the cost of power would be very high as compared with the price of the product, as the resistance of the bath will undoubtedly be great, due to the fact that a diaphragm will have to be used and that the anode has to be practically surrounded by a non-conducting substance, to wit, the material to be acted upon.

*Apparatus for the Electrolytical Treatment of Ores or Slimes.* Frank T. Mumford, Kalgoorlie, Western Australia, Australia. Patent No. 706,436, August 5, 1902.

The invention, according to the specification, relates to an apparatus for the treatment by electrolysis of ores and slimes for the extraction of precious metals, particularly gold, therefrom, whereby the solution of the precious metals from the ore and its deposition are effected by the aid of mercury in an easily recoverable condition. The apparatus is said to be applicable for the treatment of any auriferous ore, but to be

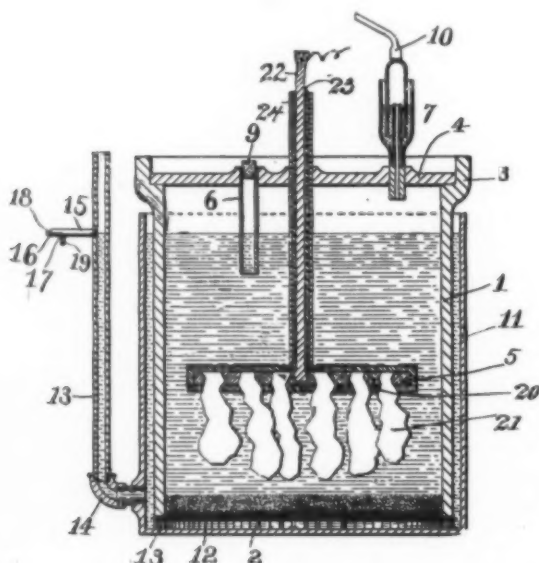
especially valuable in the case of a slimy and clay-like ore which requires very fine crushing. The apparatus consists of a steel cylinder lined on the inside with amalgamated sheet copper, and having at the bottom a layer of mercury. This cylindrical shell forms the cathode of the apparatus, while the anodes are formed by a number of carbon or iron rods, passing insulated through the closed ends of the cylinder and running parallel to the sides. The cylinder can be rotated about its horizontal axis. As electrolyte is claimed a solution of cyanide of potassium or sodium, chloride or bromide of sodium or other suitable salts, either jointly or separately. The operation is described as follows: The cylinder is filled with the crushed ore and electrolyte, and started to revolve slowly. The current is then introduced, which is expected to dissolve the gold by means of the anion liberated and deposit it as amalgam on the cathode. Any coarse particles of gold in the ore are supposed to be immediately amalgamated by contact with the mercury. At the end of the operation the mercury is run off, the amalgam squeezed out and retorted. The process, on reading the specification, appears to be as easy, as is termed in the common vernacular, as rolling off a log. One fills the gold ore and electrolyte into the cylinder, turns on the electricity, turns the crank, as it were, and finds the gold at the end in the mercury. But when one recalls the dozens of apparatus of similar construction which have been patented for the same purpose and have died a peaceful death in the archives of the Patent Office, one cannot help but feel a little skeptical about the practical success of this one.

*Electrochemical Apparatus.* Chauncey C. Clark, Philadelphia, Pa. Patent No. 706,529, August 12, 1902.

The object of this invention is to construct a closed apparatus for the electrolysis of chemical solutions, as the production of bleach liquors by the release of chlorine from common salt, the electrodes and their connections being kept at a low temperature. It is said that in consequence of the low temperature the electrical resistance of the electrodes is so largely diminished that the life of the electrodes and their connections is greatly prolonged. The apparatus consists of two copper or iron cylinders, one within the other, so that the inner one is completely surrounded by cooling liquid. In addition to that the inner cylinder is traversed lengthwise by copper tubes, arranged similar to the tubes in a tubular boiler, which tubes serve also for the circulation of cooling liquid. The electrodes are screwed to bars running the whole length of the inner cylinder, parallel to the tubes and the electrode material is platinum for the anodes and zinc for the cathodes. The cooling fluids enumerated are "liquid air, ice water, compressed air or other suitable or available cooling fluid or material." This is the gist of the invention, but enough will be gathered from this to show that the inventor has upset all our ideas about the electrolytic production of bleaching liquors and the chemical action of the product obtained thereby. Up to now we had supposed that free hypochlorous acid, which, according to Foerster and Bischoff's researches, exists in bleaching solutions prepared by electrolysis and to which their strong bleaching action is due, would energetically attack metals like zinc and copper and destroy them in a very short time. Preceding inventors in that line had proposed stoneware apparatus and had to cool their solutions in order to prevent the formation of chlorate, though they could not afford to use liquid air or ice water. Then a high current density and reversible electrodes as in the well-known Kellner apparatus were supposed to be absolutely necessary. Furthermore, it was thought that sheets of platinum of sufficient strength to resist for any length of time as electrodes were prohibitive as far as their cost was concerned, a reason why Oettel used carbon electrodes in his apparatus. An active circulation of the electrolyte was also considered necessary. This is all done away with in the apparatus under consideration. It would perhaps be interesting to look into it after a current of say 200 amperes has been going through it for half a day and see what happened.

*Electrolytic Cell.* Adolph Sommer, Cambridge, Mass. Patent No. 707,804, August 26, 1902.

The specification describes a new form of an electrolytic diaphragm cell, which is reproduced in the adjoining figure. The cell consists of an iron tank 11, which forms the outer part of the cell and serves as cathode at the same time. In it is placed a stone or earthenware tube 1, having a flange 3 in which is secured a cover 4, with water-seal tube 7 and replenishing tube 6 closed by cork 9. Through the center of the cover there enters the anode 5, consisting of a metallic base 20, in which a plurality of pieces of carbon 21 or other suitable substance are embedded. A rod 22 is in connection with the metallic base, which rod is covered by a coating of asphaltum or other suitable material 23 and a sleeve 24 of glass, etc., serving to protect the covering. The anode is somewhat smaller than tube 1, allowing space for gas and liquid to pass between. Between the lower end of tube 1 and the bottom of tank 11 are interposed in the order named a sheet of non-fibrous foraminous material 12 and a support 13 of some non-conducting material, as glass, porcelain or stoneware. Upon the sheet 12 and inside of tube 1 is placed a layer of granular material,



SOMMER ELECTROLYTIC CELL.

as crushed glass or quartz sand, just crushed large enough so as not to pass through the meshes of the non-fibrous foraminous sheet. 13 is a discharge pipe with elbow 14 and several small branches 15, 16, 17, 18, 19. The advantages claimed for this apparatus are: First, the tubular anode compartment, making it possible to remove the cover and gain access to the anode very quickly; second, the iron tank which constitutes the cathode; third, the peculiar construction of the diaphragm, which is made of a sheet of foraminous non-fibrous material having small openings and a layer of granular material which lies on the sheet and closes the openings.

#### IMPROVEMENTS IN STORAGE-BATTERY CONSTRUCTION.

*Separator for Electric Accumulator Plates.* Richard A. Katz, Berlin, Germany. Patent No. 705,630, July 29, 1902.

This invention provides a separator for electric accumulator plates of non-conducting material, consisting of a combination of two wide-meshed gratings, of which the intersections of the one cross the open spaces of the other. Thus ample space for passage of the electrolyte is assured and the plates are supported at the same time along numerous uninterrupted lines.

*Composition for Use in Secondary Batteries.* Carl Oppermann, London, England. Patent No. 706,444, August 5, 1902.

The object of the invention is to render the active material harder and less liable to disintegration, which the inventor proposes to do by making up the lead oxide into a paste with diluted sulphuric acid and adding a solution of Trinidad asphaltum, preferably dissolved in benzine and diluted with alcohol. After applying the paste to the support he dries it at a low temperature to drive off the solvent of the asphaltum, and claims that this acts as a cement and increases the hardness of the active material.

*Electrode for Storage Batteries.* Charles W. Kennedy, Rutledge, Pa. Patent No. 706,568, August 12, 1902.

The object of the invention is to provide an electrode with a maximum amount of active surface and a minimum amount of weight, which he attains by a peculiar mechanical construction which is described at length in the patent.

*Electrode for Storage Batteries.* Henry Woodward, London, England. Patent No. 707,666, August 26, 1902.

The invention consists in a construction designed to reduce the weight of storage batteries and at the same time to provide better means for retaining the oxide of lead upon the positive and negative plates. The inventor forms the positive plate of his accumulator from thin strips or tapes of lead and claims "an accumulator plate comprising a plurality of strips crossing each other and pivotally connected together to permit expansion and contraction."

#### GALVANIC CELLS.

*Galvanic Battery.* Charles S. Schoenmehl, Waterbury, Conn. Patent No. 705,616, July 29, 1902.

This concerns an improved form of copper oxide cell designed for use in automobiles, etc., in which the electrodes are kept rigid by suitable mechanical means, which allows the use of the cell in any place where it would be subject to rough handling and shaking.

*Electric Battery.* Edward R. Gill, New York, N. Y. Patent No. 705,919, July 29, 1902.

This patent embodies various mechanical features which aim to facilitate the connection of cells in series and the removal of any of them without disturbing the circuit. It is, as the inventor describes it, an improved form of socket whereby cells made in accordance with his invention are quickly and easily put into or out of circuit without interfering with the operation of the battery.

*Battery.* William L. Panikoff, New Haven, Conn. Patent No. 706,340, August 5, 1902.

The specification says: "This invention relates to batteries, and more particularly to that class of batteries in which it is desired to use different strengths of current, and has for its object the construction of a device by which a series of batteries are adapted to be used singly or in series according to the wish of the operator, and that when not in use the plates of the batteries may be held in position free from the flint contained in the jars themselves." A mechanical construction for this purpose is described in detail.

*Electrochemical Generator.* Harry S. Amwake, Camden, N. J. Patent No. 12,019, reissue, August 12, 1902.

The inventor proposes to construct a cell "in which the chemical action shall not markedly exceed the rate at which the electric current is drawn from the cell," and also to "secure a cell giving a high and constant electro-motive force." For this purpose he arranges a current-conducting baffle plate or partition between the electrodes, and claims that "thereby the movement of the electrolyte, due to differences of temperatures between different parts of the same, will take place in a devious or circuitous path, whereas the electric current may pass directly through the conducting baffle from one electrode to the other."

**Chemical Generator of Electricity.** Edward Lacey Anderson, St. Louis, Mo. Patent No. 706,631, August 12, 1902.

The invention consists of a cell with an aluminum and a carbon electrode, and an electrolyte composed of a suitable halogen salt or salts, i. e., a fluoride or chloride, or both—an acid and preferably in practice a depolarizing agent.

**Galvanic Battery.** Eason L. Slocum, Pawtucket, R. I. Patent No. 707,363, August 19, 1902.

The cell is designed to furnish a current either of quantity or intensity, as the inventor provides a containing jar which has five separate positive electrodes and also the negative electrodes made in divisions.

**Electrochemical Generator.** Harry S. Amwake, Camden, N. J. Patent No. 707,372, August 19, 1902.

This is an improvement on the cell described above and consists in using a baffle plate in connection with both the negative and positive electrode, that is to say, in using one baffle to surround the positive electrode or electrodes, and another baffle to surround the negative electrode or electrodes.

**Electric Battery.** Ernest A. G. Street, Paris, France. Patent No. 707,731, August 26, 1902.

The invention provides a detachable vessel to be connected to the electrode of a galvanic cell, which vessel contains the depolarizing agent. By the construction shown in the specification it is possible to renew the depolarizing agent quickly without interfering with the electrode.

#### MISCELLANEOUS.

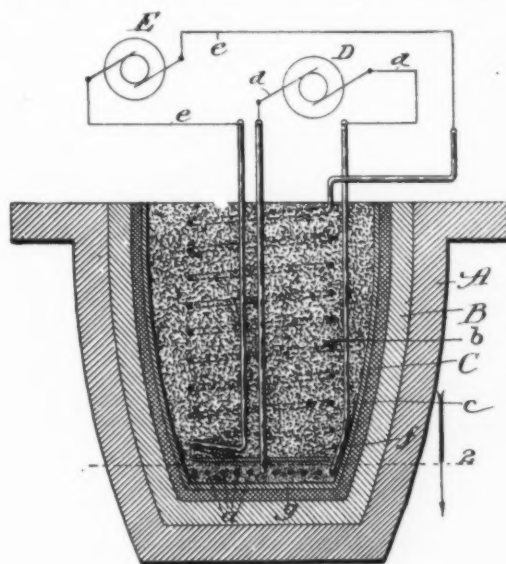
**Method of Electrodepositing Metal on Lace.** John Andrew Daly, Washington, D. C. Patent No. 707,306, August 19, 1902.

The inventor takes the articles of lace or other flexible material on which he wants to get a metallic deposit and prepares them in the usual manner by coating their surface with an electrical conductor, either by rubbing graphite on them or in another suitable way. He then lays them on a wire basket and winds a number of turns of fine wire around them and the basket. Thereby he brings the articles into contact with the wire and the basket at a great many places and as soon as the basket is made cathode in an electrolytic bath, the deposit starts right away at the contact points and from there spreads over the articles to be coated. He does not allow the current to act more than a few minutes, or just sufficient to give stiffness to the articles, because they would stick to the wire if left too long and would thus be spoiled. After they have been stiffened in this way they may be suspended into the electroplating bath by metallic hooks, and the deposit of metal may then be continued.

**Method of Treating Metallic Oxides in the Production of Metals and Alloys.** Frederic C. Weber, Chicago, Ill. Patent No. 705,727, July 29, 1902.

This invention is claimed to be an improvement in the process of producing metals by reduction of their oxides by means of metallic aluminum. In the Goldschmidt process, introduced into practice by the Allgemeine Thernit Gesellschaft, of Essen, Germany, this reduction is accomplished by mixing finely-divided aluminum with the metallic oxide to be reduced and starting the reduction at one point by igniting a strip of magnesium wire inserted into a cartridge filled with an easily reducible oxide, such as peroxide of barium. The easily reducible oxide is reduced by the magnesium and the heat propagates itself through the entire mass. It is claimed by the inventor of the process under consideration that various disadvantages, such as explosions, contamination of the reduced metal by magnesia, etc., can be avoided by using his method. The arrangement of the apparatus is as follows: *A* represents the outer vessel; *B* the lining of lime or graphite; *C* a lining of mineral wool and magnesia; *D* and *E* two sources of electrical energy. *a* is a coil of small aluminum wire placed in the bottom of the crucible, *b* is a helix of aluminum wire placed within the vessel above the coil, *c* a thimble

of aluminum, *g* is finely-powdered oxide, *h* is the coarser oxide which is to be treated and *f* is a sheet of tissue paper to prevent the mixing of the fine and coarsely-powdered oxide. The process is started by heating the larger coil by means of a current to such a temperature below the melting point of aluminum as to drive all the moisture and water of combustion off. After this a current of sufficient intensity to melt the small



WEBER APPARATUS FOR REDUCING OXIDES.

aluminum coil in the bottom is turned on, with the result that the reaction starts there and propagates itself through the whole charge, producing a molten corundum slag and the desired metal.

#### THE CONDUCTIVITY AND FREEZING POINTS OF AQUEOUS SOLUTIONS OF CERTAIN METALLIC SALTS OF TARTARIC, MALIC AND SUCCINIC ACIDS.\*

By Prof. O. F. Tower.

In an article which appeared recently in the *Journal of the American Chemical Society*, it was shown that the molecular conductivities of nickel and cobalt tartrates in aqueous solution were abnormally small, and also that the freezing-point method yielded apparent molecular weights considerably greater than those calculated from the simple formulas. The explanation was offered at that time that this behavior might be due to polymerization of the molecules. The object of this paper is to see if this behavior is confined to the tartrates alone of nickel and cobalt, and also to see if the nickel and cobalt salts of certain other acids are related to the tartrates. The determinations with nickel and cobalt tartrates have been repeated and determinations have also been made with magnesium, barium and manganese tartrates (these were the only ones of this class found to be sufficiently soluble), and nickel, cobalt and magnesium malates and succinates. The molecular conductivities of these salts at dilutions of 32 and 1,024 liters follow:

MOLECULAR CONDUCTIVITY.									
V	Tartrates			Malates			Succinates		
	Ni	Co	Mg	Ni	Co	Mg	Ni	Co	Mg
32	18.1	30.5	77.5	18.1	27.8	63.6	72.7	76.6	90.9
1024	93.0	118.0	156.0	72.3	90.3	146.0	156.0	157.8	161.5

The molecular weights calculated from the simplest formula for the respective salts, together with the molecular weights

\* Abstract of a paper read at the Pittsburg meeting of the Amer. Chem. Soc'y, July, 1902.



found by the freezing-point method for a dilution of 16 and 32 liters, is given in the following table:

	Tartrates			Malates			Succinates		
Mol. Wt. from formula .....	Ni	Co	Mg	Ni	Co	Mg	Ni	Co	Mg
	207	207	173	191	191	156	175	175	140
Mol. Wt. freezing point { $v=16$	230	244	122	164	179	180	158	111	82
{ $v=32$	196	207	109	140	150	150	100	103	77

In addition to the tartrates of nickel and cobalt, the malates of these same metals show similarly low conductivities and high molecular weights. The succinates of nickel and cobalt act normally, as do the various other tartrates, malates and succinates investigated. These results seem to show that the presence of the hydroxyl groups in the tartaric and malic acids have some effect in causing this peculiar behavior of the nickel and cobalt salts. And the fact that the molecular weights found for the malates seem to indicate that the polymerizing effect increases with increase in hydroxyl groups.

However, after the above work had been finished, similar determinations were made with the nickel, cobalt and magnesium salts of malonic and tartronic acids to see if this would throw any light on the influence of the hydroxyl groups. Tartronic acid is related to malonic acid as malic is related to succinic acid, it was, therefore, to be expected that if the presence of the hydroxyl group tends to cause polymerization of the nickel and cobalt salts, the molecular conductivities of the tartronates of these metals would be considerably less than the molecular conductivities of their malonates, and that the freezing-point method would yield greater molecular weights in the former case than in the latter. The results obtained did not confirm this conclusion.

Although the nickel and cobalt salts possess lower molecular conductivities and higher apparent molecular weights than the magnesium salts, yet the results with the tartronates do not differ materially from those with the malonates. The hydroxyl group, therefore, does not seem to be the determining influence in the peculiar behavior of these nickel and cobalt salts. Just what causes this exceptional behavior of nickel and cobalt tartrates and malates must be left undecided. But there is undoubtedly something in the nature of the nickel and cobalt themselves which causes aqueous solutions of their organic salts in general to offer greater resistance to the electric current than similar salts of the other metals investigated, for example magnesium.

### TESTING CARBON ELECTRODES.

The following is an abstract of a paper read at the Niagara Falls meeting of the American Electrochemical Society, by FRANCIS A. J. FITZGERALD:

In both electrochemical and electrometallurgical processes in which carbon electrodes are used the determination of their density is important. The general efficiency of the electrodes depends on the nature of the carbon and on the methods used in their manufacture, and much may be learned on these points by a determination of the density. Two different densities are to be distinguished; the real density and the apparent density. The apparent density is equal to the weight divided by the volume as a whole. From these two we get the porosity which

$$\text{is equal to the } \frac{\text{real density} - \text{apparent density}}{\text{real density}}.$$

The determination of the *real density* is difficult on account of the persistence with which amorphous carbon and graphite retain air.

The apparatus used in this determination are as follows: a volumeter graduated to 100 c. c. in divisions of 0.2 c. c., and fitted with a rubber stopper through which passes a glass tube, the end of the glass tube inside the volumeter being drawn to a point and bent back; a water bath in which the volumeter is

placed to keep the temperature constant; a vacuum pump; kerosene oil, such as "Acme Crown" kerosene, which has a high flashing point and is free from the volatile paraffine. Oil is used in the volumeter because it will not readily wet carbon.

The method of determination is as follows: A specimen of the carbon or graphite to be tested, weighing at least 30 grains, is cut from the electrode and weighed. The volumeter is partly filled with kerosene and is placed in the water bath. A reading of the volumeter is then taken, the specimen introduced and the instrument connected with the vacuum pump. When the pump gauge has shown the maximum attainable vacuum for a period of about ten minutes, the volumeter is disconnected and a second reading taken. The operation is then repeated and another reading taken. This method is followed until two consecutive readings are the same. The difference between the last reading and the original reading is the real volume, and from this the real density can be calculated.

There is no evaporation of oil, but in the beginning a serious loss of weight was found, which was due to the drawing off of a fine spray caused by the bursting of air bubbles at the surface of the oil. This difficulty was overcome by drawing out the glass tube and bending it back on itself.

The pressure is reduced to about 20 mm. of mercury by a filter pump. There is no constant error in the observations due to this imperfect vacuum.

In a determination by this method and by the specific gravity method, the following results were obtained:

Density determined by volumeter.....	2.1887
Density determined by specific gravity.....	2.1930

The *apparent density* is determined by giving the electrode a light coat of shellac, putting it into a volumeter which contains water, and then observing the volume of water displaced by the electrode.

The second part of the paper deals with the detection of amorphous carbon and graphite in carbon and graphite used as electrodes. Graphite shows greater resistance to oxidizing and disintegrating actions than any other form of carbon. To obtain the best results in electrolytic and electrometallurgical work the electrode should contain no amorphous carbon, and it is important to have some method of testing whereby amorphous carbon can be detected. The following is a method suggested by Berthelot: About 0.5 gram of the finely powdered electrode is introduced into a test tube containing 10 c. c. of nitric acid, and to this is added cautiously 4 grams of potassium chlorate. The test tube is then placed in a water bath and kept at a temperature of 60°, until all action is over, that is, for about ten or twelve hours. The nitric acid is then poured off, the residue is thoroughly washed with hot water by decantation and dried. By repeatedly treating the specimen in this way all the amorphous carbon present is converted into a yellowish-brown soluble substance, while the graphite yields a yellow insoluble substance, which has been named graphitic oxide by Berthelot. When a mixture of graphite and amorphous carbon is under observation the presence of the latter is easily recognized by the reddish-brown color of the water used in washing the oxidized products.

In the Acheson graphite electrode there is an entire absence of amorphous carbon, the electrode consisting wholly of graphite.

When it is desired to test an electrode to determine whether it is composed wholly of amorphous carbon or contains a certain amount of graphite a method of Staudenmaier may be used. The specimen to be tested is treated once with the oxidizing mixture, washed, heated in the water bath with a solution of potassium permanganate and sulphuric acid, and finally treated with an excess of hydrogen peroxide. If the specimen consisted wholly of amorphous carbon, a clear solution of a reddish-brown color is obtained, but if any graphite is present there remains an insoluble residue of a yellow or greenish-yellow color.

## SYNOPSIS OF ARTICLES IN OTHER JOURNALS.

*A Summary of Articles on Electrochemistry and Allied Subjects Appearing in American and Foreign Periodicals.*

BY CARL HERING.

### INDUSTRIAL ELECTROCHEMISTRY.

**Copper Refining.**—The long series of articles by PHILIP, of which the first parts were noticed in the synopsis last month, have now been concluded in the *Lond. Elec.*, August 15th, 22d and September 26th. The whole serial is to be published in book form, the portions published in advance being merely portions of this book. The concluding parts are limited to copper refining. Continuing his analysis of the costs he finds that the cost in dollars of dynamos and switchboard, including erection, is  $0.28 \text{ T D}$ , in which T is the output in tons per year and D the current density used in amperes per square foot. The cost of electrolytic vats is  $60 \text{ T/D}$ . The cost of the electrolyte required is  $0.30 \text{ T S/D}$ , in which S is the price of copper sulphate crystals per ton in dollars. The cost of the copper anodes is  $\text{A T P/D}$ , the thickness of the anode plates in inches being A and the cost of anodes per ton, P. The capital invested in copper in stock, including cathodes and copper leads, etc., is  $1.3 \text{ A T P/D}$  plus  $4.05 \text{ R T/B}$ , in which R is the price per ton of the refined copper of which the leads are made and B the current density per square inch in the copper conductors. In an example the price of the refined copper was \$375 per ton; the price of anode copper, \$350 per ton; the output of refined copper, 1,000 tons per year; the current density, 10 amperes per square foot at anodes; the price of copper sulphate crystals, \$125 per ton; the thickness of the anode plate, 1 inch, and 250 amperes per square inch allowed in the copper current conductors; then his formulas give the total capital invested as \$56,125. He then discusses the various items in the annual cost of refining. There is first the interest on capital invested; there is no depreciation except in so far as the market price may vary, but this cannot be readily taken into account; the annual cost of labor is  $0.6 \text{ W T}$ , in which W is the amount paid weekly in wages. The annual cost of melting refined copper is  $1.25 \text{ M T}$ , where M is the cost of melting one ton, and the factor 1.25 is to allow for remelting scrap anodes. The cost of fuel used for power per year is  $0.0771 \text{ T D C}$ , in which C is the cost of coal per ton. He then points out the great influence which the current density has upon the capital and annual outlay per ton of copper refined per year; there is, in fact, some particular current density which will yield the most satisfactory financial results, and this particular one varies with the price of coal, the cost of melting down each ton of refined copper into ingots, the rate of wages paid, the rate of interest paid upon the capital invested, and lastly, but most important, the difference in price at the works between the price paid for anode copper and the price obtainable for the refined copper, together with the value of the silver and gold separated from it, if this value goes to the refiner. The current density at the anode used in different plants varies between 1 and 15 amperes per square foot. He refers to a statement of Cowper-Coles that whereas formerly current densities of only 2 to 4 amperes per square foot were thought permissible, current densities of from 15 to 20 amperes are now said to be used in some establishments. The author states that he does not know of any electrolytic copper refinery in which a greater current density than about 15 amperes per square foot has been successfully used over any length of time, and he is strongly of the opinion that it cannot pay to use a greater current density than 16 amperes per square foot at the outside, if the product of the refinery is merely pure refined copper, and not, as in the Elmore process, some manufactured, or partly manufactured, article of copper, like sheets,

tubes, wires, etc. He uses his formulas for calculating the different items of the capital investment and the annual charges, to show how all these items vary, when the current density is varied between 5 and 20 amperes per square foot, and from the results obtained it appears that the percentage profit on the capital invested, under the particular conditions stated, will be greater when the current density at the anode is about 15 amperes per square foot. The increase in the current density is not only limited by the question of prime cost, interest and depreciation, but also by other important factors, such as the alteration of the mechanical character of the electro-deposited copper on the cathode and the alteration of its chemical nature when the current density increases. Unless some special means are used, the copper which is deposited with current densities much above about 14 or 15 amperes per square foot, tends to take a crystalline and loose form, finally becoming long growths which may short-circuit a vat. Furthermore, if the electrolyte contains many impurities the high current density is favorable to the precipitation of arsenic and antimony together with the copper, thus greatly reducing its value. Concerning the series and parallel arrangement of the vats, he says that the amount of copper used in the connections between the vats and the dynamo is greater in direct proportion to the number of sets of vats there are in parallel; and the amount of copper in the form of copper is also greater per ton output of copper the greater the number of vats used on account of the extra connections between each vat. Economy in copper is, therefore, attained by having all the vats in series and having the vats as large as possible. The amount of copper is also less the greater the current density. He finally makes a few remarks on the size and the number of the vats and on the best voltage of the dynamos used for copper refining.

**Zinc Plating.**—To electrochemists, at least to those who have studied the relative electrochemical behavior of various metals, it is well known that when iron is in contact with zinc, or any other more electropositive metal, the iron cannot rust, as there exists continually an electrochemical-reducing action at the iron, at the expense of a corresponding oxidation of the zinc, and it is for this reason that galvanized iron does not rust. But this is also the reason why iron which has been covered with zinc by mere insertion in molten zinc is called "galvanized." The term galvanizing, as often applied to the process of coating the iron with zinc by dipping in molten zinc, is therefore quite irrational, as the only galvanic action which exists is the subsequent electrochemical-reducing action when the galvanized or electrofied iron becomes moist, and as the metal is then always cold the term "cold galvanizing," which is now often used for the process of electroplating with zinc, is therefore used for just the reverse process to which the term strictly applies, namely, for the reduction instead of the oxidation of the zinc. Similarly the term "electrogalvanizing" is quite incorrect, it being tautological. While such incorrect words may get into our not too consistent English language through the commercial elements, yet there seems to be no excuse why they should be sanctioned by electrochemists who understand their true meaning and origin. However this may be, a recent article by BURGESS and HAMBUECHEN in the *Electrical World and Engineer*, September 13th, under this unfortunate heading, is decidedly better than its title. In this they first discuss the prevention of the corrosion of iron by means of a coating of zinc and the advantages of the electrolytic

deposition of zinc over the hot process. The commercial processes by which "electrogalvanizing" is now being performed may be subdivided into two classes, according to whether use is made of soluble or insoluble anodes; the former is used almost exclusively in this country and the latter in England. The Cowper-Coles process employs a lead anode, which is practically unattacked by the sulphate solution, so that free acid is continually formed. The acidity of the solution, which is drawn from the tanks, is neutralized by bringing it into contact with zinc dust in contact with coke. The reason for preferring a soluble zinc anode is that circulation and regeneration of the electrolyte are theoretically unnecessary, and the use of auxiliary apparatus is done away with to a considerable extent; the amount of power required is also considerably smaller. The objections to zinc anodes are two: first, during the operation there forms upon the surface of the zinc a scale or coating, usually black in color, which interferes with the dissolution of the zinc; second, for satisfactory operation the solution must be kept at a certain degree of acidity. The deposition of a good quality of zinc coating depends almost entirely upon the composition of the solution; zinc sulphate is superior to chloride, but the addition of some other ingredient is required, among the most serviceable of which is aluminum sulphate, but the authors deny that in this case an alloy of aluminum and zinc is deposited. In the electro-deposition of metals for plating purposes they claim that the physical character of the deposit is better in being more compact, uniform and non-crystalline, when thrown out of solution by secondary rather than by primary action; in the solution under question, the aluminum is the more positive ion, which, on liberation, reacts with the zinc sulphate to deposit zinc. Alum is very frequently used in plating solutions, and its value lies in its being a cheap source of aluminum sulphate. When cast iron or iron containing a considerable amount of graphite is cleaned with acid, the graphite is unattacked, and as the iron is dissolved away, more and more comes to the surface, which then becomes an iron surface to which are attached innumerable small particles of graphite; in trying to electroplate this each particle not only refuses to receive a deposit, but protects the iron in its immediate vicinity from receiving it. This shows the necessity of using some other method than the acid alone for preparatory cleaning of cast iron; a cast-iron surface prepared by the sand blast receives its deposit most readily. The shape of the anode is an important factor in zinc plating; it should be designed so as to conform with the shape of the article to be plated, making the distance from the anode to each portion of the cathode as uniform as possible. As a general rule current density at the anode should be lower than at the cathode. To increase the depth of coatings, recourse is frequently had to "striking" solutions; one of its principles is the use in the zinc-plating solution of a metal salt, the metal of which is more electronegative than the zinc, the most satisfactory of such salts being tin chloride, which is added to the solution in small quantities from time to time. Another principle for striking solutions is the use of an electrolyte in which the zinc does not exist to any appreciable extent, as an electropositive ion, and in which it is, therefore, deposited entirely by a secondary reaction; Newman found the following solution very satisfactory: 0.4 pounds of potassium cyanide is dissolved in 1 gallon of distilled water, to which is added as much zinc carbonate as will dissolve; a current density of 14 to 25 amperes per square foot produces an excellent deposit; but the coating is formed slowly, and there is the disadvantage that the substance is very poisonous.

**Calcium Carbide.**—In an article by Pio in the *Lond. Elec.*, August 29th, he says that in Italy the calcium carbide industry is progressing rapidly, and the number of furnaces operated with continuous or polyphase current is continually increasing. It is only since last year that this industry has become profitable in Italy. Since 1896 acetylene has been introduced into commercial use in small villages, and is now being applied

on railways for train lighting. Another field of application is the acetylene gas motor for small industries, but this class of motor has not yet been sufficiently improved to tempt experimenting on a commercial scale. The price of calcium carbide has been raised lately to \$87.50 per ton, as against \$50 last year, which seems to be the result of a syndicate which was recently constituted on the Continent. In a recent publication of Memmo the conditions required to render the industry remunerative are stated to be as follows: The price of the plant, including machinery, furnaces and all the necessary supplies, must be not higher than \$100 per horse-power installed. A certain ratio between the number of tons of carbide produced and the number of effective horse-power must exist. The capital expended must be amortised in ten years; this corresponds to a sinking fund of \$8 per ton, so that, including freight, loss, profits, etc., the price to customers does not exceed \$60 per ton. At least 6 per cent. must be paid on the capital invested.

**Furnaces.**—Among the several articles that have appeared recently on electric furnaces is one by HAAGN in the *Zeit. f. Elektrochemie*, July 31st; it is a Bunsen Society paper and describes a furnace for laboratory purposes, made by Heraeus. It has the advantage that it contains only 1-6 to 1-10 the weight of platinum, which is required in wire furnaces of equal size and durability; this allows, of course, a great saving; the platinum consist of foil 0.007 millimeter in thickness. The furnace is said to be very easily adjustable by the insertion and variation of a series resistance; it is said to follow exactly any variation of the currents. The tubes on which the platinum foil is mounted are best made of china or glass; magnesia is not suitable for high temperatures, as it then begins to become a good electrolytic conductor and the cathodic products of electrolysis destroy the platinum very quickly. At temperatures of 1,500° similar phenomena take place in the otherwise excellent and very refractory so-called Marquardt mass of the Berlin china factory; the temperature is limited by this phenomenon; he has, however, obtained a temperature of 1,700° for a short time, but the china then gets soft. The best form of the furnace is a tube, which is not too wide and not too short. The furnace can be made for any voltage up to 220; lower voltages are better for very high temperatures. In the discussion Heraeus said that he has succeeded in making a non-electrical furnace in which temperatures up to 2,200° can be produced; he uses for this purpose an iridium tube which is suitably placed in a lime furnace, and is heated by means of an oxy-hydrogen flame. The temperature was measured by means of a thermocell, consisting of wire of absolutely pure iridium and an alloy of 90 per cent. of iridium with 10 per cent. of ruthenium. This cell was compared up to 1,650° with a thermocell calibrated by the Reichsanstalt, and the higher values were "calculated."

On the subject of making steel there were two articles; in one by SEIDENER, published in the *Zeit. f. Elek.*, August 24th, the plant in Gysingen, Sweden, is described. When two years ago the first electric furnace was installed, it yielded 575 pounds in twenty-four hours with 78 kw.; it was used for experimental purposes, but now a larger furnace has been built, and it is claimed that with a 300 horse-power turbine, directly coupled with a generator, this new furnace will give 1,500 tons per year, which means that 72 horse-power give one ton per day. In other electric furnaces it is said that 50 or even 30 horse-power will give one ton of steel per day. It is suggested to use the wasted gases of blast furnaces to drive gas engines, and, if the power cannot be used otherwise, to utilize it in electric-steel furnaces.

The other is a note in the *Lond. Elec.*, September 5th, which states that the possibilities of the electric furnace as a rival of the blast furnace, for the smelting of iron ores, are now being tested at several places in Europe. The Stassano process has been under trial in a plant of 1,500 horse-power capacity at Darfo, in Northern Italy. After inspecting these



furnaces in operation about a year ago, Dr. Goldschmidt, of Essen, reported favorably on their prospects. But the capital available for these experimental trials has now been exhausted, and it was announced in January that the company owning the Darfo plant was in liquidation. From figures published by those financially interested in the Stassano process in 1899, it appears that 2.7 horse-power hours were expected to yield one kg. steel in the electric furnace, and that a saving of \$7 per ton of steel was estimated as compared with the cost by the ordinary smelting process in Italy. Whether the liquidation of the company is due to the failure of the Stassano process to attain these results, or is simply due to a shortness of working capital, is not known. Similar trials of the electric furnace for the reduction of iron ores are being conducted at Prague in Austria, at Le Praz in France, and at Gysingen in Sweden, as noticed in the paragraph above, and at the latter place 1,200 kg. steel are said to be produced per day by the Kjellin process. If steel of good quality can be produced in a single operation by the electric furnace from iron ores of average composition, these new processes of ore reduction may have an important future.

*Chlorine and Soda.*—Although this is an important electrochemical industry, little has appeared in the press lately. GLASER gives an account, in the *Zeit. f. Elektrochemie*, August 7th, of an investigation of the Solvay-Kellner mercury cathode process on a laboratory scale, the chief results of which were that a low ampère hour efficiency is due chiefly to the depolarizing action of the chlorine on the alkali amalgam, and that the decomposition of the water is of less importance. Also that without a diaphragm a good efficiency can be obtained only at high-current densities, but with specially-prepared diaphragms the efficiency is good at lower-current densities also. J. B. C. KERSHAW begins an illustrated article on chlorates in the *Elec. Rev.*, October 4th. After some introductory notes on the reactions and their equations, he describes the Gall and Montlauer and the Carlson chlorate cells.

*Purification of Water by Ozone.*—There is an illustrated description in the *Sc. Am. Sup.*, August 23d, of the Siemens & Halske experimental plant for purifying water by ozone near Berlin.

#### THEORETICAL AND EXPERIMENTAL.

*Faraday's Law.*—Fortunately for electrochemists this law, which is the foundation of the whole science of electrolysis, has successfully withstood all attacks made on it, even though at first sight it sometimes appears to fail. Nevertheless further proofs of its accuracy, such as those given in a recent A. A. A. S. paper by T. W. RICHARDS, abstracted briefly in *Science*, August 22d, are always of interest, especially as he finds that the law applies to aqueous solutions and for ordinary temperatures. He reviews his researches in co-operation with Collins and Heimrod, and describes some more recent work done with the assistance of Stull. The weight of silver deposited in the "porous cup voltameter" of Richards and Heimrod, was compared with the weight deposited by the same number of coulombs from a solution of argentic nitrate in fused sodic and potassic nitrates at 300°. After making some corrections and subtracting the weights of alkaline nitrates included in the silver crystals, it was found that the weights were identical within the limits of error of the experiment, namely, about 0.005 per cent. This investigation places Faraday's law among the most exact and invariable of the laws of nature.

*Faraday's Law and Salt Vapors.*—That Faraday's law applies also to vapors is shown by WILSON in some experiments in which he passed electricity through flames containing salt vapors, an account of which may be found in the *Phil. Mag.* for August. Former experiments had shown conclusively that conduction through salt vapors is accomplished by means of ions of some kind and is therefore to this extent at least analogous to conductions through solutions. However, determinations of the velocities of the various ions in

salt vapors show that the ions generally behave as if they were much heavier than single atoms, and that the positive ion always moves more slowly than the negative. The experiments described in the present paper show conclusively that above 1,300° C. there is a very close analogy between salt vapors and liquid electrolytes; Faraday's laws of electrolysis are strictly applicable to salt vapors. It is probable that the gaseous ions attract neutral molecules to themselves, which accounts for their small velocities; and apparently the positive ions condense many more molecules in this way than the negative, the latter, therefore, move much the faster. But this condensation, which appears to be peculiar to ions in the gaseous state, need not affect the number of ions produced by the dissociation of one salt molecule or the charges which they carry. He shows that a salt in the state of vapor gives rise to the same number of ions carrying the same charges as a salt in an aqueous solution; or, in other words, the capacity of a salt vapor for transporting electricity is the same as the capacity of an equal amount of salt in the state of solution. He describes in detail the arrangement of his experiments and gives curves showing how the current with a constant e. m. f. of 840 volts, varies with the temperature when solutions of one gram in a litre are sprayed. In each case the current at first rises rapidly to a nearly constant value, which is maintained over a wider or shorter range of temperature. On approaching 1,200° the current again begins to rise rapidly, and somewhere above 1,300° it suddenly attains a nearly constant value. This nearly constant value seems to represent the maximum current which the amount of salt passing through the tube can carry, for it is affected very little by increasing either the temperature or the e. m. f. This current he calls the "saturation" current for the particular salt used. The values of this maximum current are given for various salts in a table. From this table it appears that the maximum current of electricity transported by a salt vapor is proportional to the amount of salt passing between the electrodes, and that the saturation current with a definite amount of any salt passing between the electrodes is inversely as the chemical equivalent of the salt. This amounts to a proof that Faraday's laws of electrolysis apply also to the saturation current carried by a salt vapor. The amount of salt per second of unity electrochemical equivalent which would correspond to a current of 1 ampère, is 0.0101 milligram. Now, 1 ampère second liberates in electrolysis 0.0104 milligram of hydrogen, so that it appears that the factor of proportionality is nearly the same for salt vapors as for electrolytes.

*Unipolar Currents.*—A peculiar apparent departure from Ohm's law was observed by CHRISTIANSEN in certain electrolytes, and is described in a paper in the *Ann. d. Phys.* No. 8, an abstract of which may be found in the *Lond. Elec.*, August 8th. He applies the term unipolar current to the current through mercurous nitrate in nitric acid, with mercury electrodes, because this current greatly depends upon the size of the cathode, but not on the size of the anode. The irregularity observed is, that under certain conditions the current is independent of the e. m. f. The nitric acid alone begins to be electrolyzed at 1.7 volts. The mercurous nitrate acid as a depolarizer, and is electrolyzed even at the smallest voltage, but after some time hydrogen is also evolved, giving a counter e. m. f. When the applied e. m. f. is increased, the counter e. m. f. also increases, and it appears that the difference of applied and counter e. m. f. remains constant up to 1.7 applied volts, and hence the current is independent of the e. m. f. It varies, however, directly as the surface of the cathode and as the percentage of mercurous nitrate.

*A Thermochemical Constant.*—That many curious and important relations exist between the constants of nature has long been suspected, and each discovery of a new one adds greatly to our knowledge of these important values of physical properties, which as a rule must be determined empirically, sometimes with great labor and doubtful accuracy. Any such

connecting links between two sets of apparently independent physical properties, at once give an indication of the accuracy and true values of both, and are a great help in discovering many of nature's secrets in relation to the complicated inter-connection of various apparently independent properties. One such constant, for instance, is the product of the atomic weights of elements and their specific heats, and called the atomic heat, which is practically the same for nearly all the elements, and is really the number of calories required to raise 1 gram above 1° Centigrade. Another interesting constant relation of a similar nature has been found recently by F. W. CLARKE, as shown in a recent A. A. S. paper, abstracted briefly in *Science*, August 22d. From a study of the heats of combination of organic compounds as determined by Thomsen, he finds a constant relation which is identical in value with the neutralization constant of strong acids and bases. Thomsen's data relate to substances burned as gas, with the production of gaseous carbon dioxide and liquid water. By a simple correction applied to the last-named factor all the equations of combustion may be reduced to the gaseous form throughout, under uniform conditions of temperature and pressure. When so adjusted, and by the application of a definite formula, nearly every equation yields the above-mentioned constant. Its average value in 66 cases is 13,773 small calories. From this constant and the original equations, the conclusion is reached that the absolute heat of formation, from gaseous, dissociated atoms of the aliphatic hydrocarbons and their simpler derivatives, is proportional to the number of atomic linkings within the molecule. In this calculation every linking counts as one, and single, double or triple unions between carbon atoms become identical as regards their thermal value. The conclusion is revolutionary, but it satisfies the equations which are otherwise indeterminate. The preliminary paper contains 66 verifications of the new law.

**Pulverization of Metals.**—Under certain circumstances a metallic cathode is disintegrated into an extremely fine powder which colors the solution almost like ink as it floats in it. HABER, who has made extended researches of this phenomenon, published an article in the *Zeit. f. Elektrochemie*, August 7th, in which he shows that it is due to the formation and subsequent disintegration of an alloy. He first makes some theoretical remarks on the potential of alloys in electrolytes, showing that an electrode, consisting of an alloy of two metals, has a certain distinct potential difference against an electrolyte, and this potential difference can be calculated theoretically, when the temperature and the ionic concentration of either the one or the other kind of ion is known; if the one ionic concentration is given, the other one is determined thereby. He makes some applications with reference to experiments of Herschkowitsch and others by himself and Sack. In the second part of his article he gives a general review of the phenomenon of the pulverization of metallic cathodes, a characteristic feature of which is that it takes place without any light or spark phenomenon. There are certain other kinds of pulverization of cathodes, but they do not take place during quiescent electrolysis and they have an intimate connection with electrostatic or electrothermic phenomena; the special case treated by him is a simple, purely electrochemical phenomenon. At a cathode in an alkaline solution, an alloy of the cathode material with the alkali metal is formed electrochemically; it could also be made chemically, and has the property of being decomposed in water with a simultaneous pulverization. This shows that cations, when giving off their charges at the cathode, do not rebound from the cathode, like rubber balls from a stone, but they enter into the cathode and form an alloy; this has long been known to be the case for mercury cathodes, but it is also the case for lead and tin, as is proved by the following: Alloys which pulverize, contain a relatively high percentage of the alkali metal, while those with a lower percentage decompose water quietly, without pulverization, but with a

formation of a sponge on the cathodic surface. This formation of a sodium alloy at cathodes of lead and tin, is the intermediate process by which a vivid formation of hydrogen at these cathodes in sodium hydroxide is brought about. Some metals, especially platinum, do not pulverize, but become spongy on the surface; there is a great difference in this case between acids and alkalis; the hydrogen ions, with its high mobility, enter much more easily into the platinum than sodium ions. The essential formation of hydrogen in sodium hydroxide cannot be primary, as otherwise platinum would obtain a spongy surface just as well in alkali as in acid. When a cathodic point of platinum in sulphuric acid gets black, it is a case of the formation of a spongy surface. On the other hand, one should be careful not to consider deposits of impurities as a case of a formation of sponge. Billitzer replies to some critical remarks of HABER, in the *Zeit. f. Elektrochemie*, August 28th.

**Electrolytic Preparation of New Alloys.**—COEHN, in a Bunsen Society paper, shows that ammonium, like sodium, can be deposited on a mercury cathode and then forms an alloy, but the liquid state of mercury cannot be the reason for this deposition and of other metals of high solution tension, as it was impossible to get an ammonium deposit with a cathode of Wood metal; the reason why a deposit on a mercury cathode is possible, he believes, is that an alloy is formed. He then tried to deposit alloys of light and heavy metals from aqueous solutions, not by using a cathode of the heavy metal, but by depositing both metals at the same time from the solution. It has been repeatedly stated that the electrolytic deposition of nickel can be improved when a magnesium salt is added to the solution; the reason has not been clearly understood, but the author believes that it is because an alloy of nickel and magnesium is deposited. Such alloy deposits behave quite differently from deposits of pure nickel; while pure nickel does not adhere firmly, a nickel magnesium alloy does. He has made deposits of both upon sheet iron and polished copper sheets, and found that only the alloy deposits are adhesive, while pure nickel scales off. He tried in the same way to obtain an alloy of aluminum and magnesium, but was not successful. The paper is reprinted in the *Zeit. f. Elektrochemie*, August 14th.

**Cathodic Polarization in Dilute Sulphuric Acid.**—A method for measuring the value of the polarization at cathodes of different materials is described by TAFEL in a Bunsen Society paper. It is analogous to Caspari's method of measuring the overvoltage required to develop hydrogen at cathodes of different materials; he determined the potential differences between cathode and electrolyte at which the first development of hydrogen bubbles takes place, and the excess over the potential difference between a hydrogen electrode and normal sulphuric acid was called by him the overvoltage of the respective metal; he found that of the metals investigated lead and mercury in pure sulphuric acid show the highest overvoltage; these are the same metals which Tafel has found to be the only suitable cathode materials for producing certain reductions. But while Caspari used a very small current density, Tafel uses comparatively high ones. He uses a rather large polished platinum anode, dilute sulphuric acid, and a smaller platinized platinum cathode; at a fixed current the e. m. f. has quite a distinct value which remains constant for several hours. He uses as anode a bright platinum pan, filled with sulphuric acid, in which is suspended, in a fixed position, a cylindrical platinized platinum cathode, ending at the bottom in a half globe. This form of cathode can easily be reproduced in other materials, like lead. The e. m. f. is then measured again, while the same current flows, and the difference of the e. m. f. in the two cases of platinized-platinum and lead cathodes, is the "over polarization" of the lead cathode over the platinum cathode at the given current density, under the supposition that nothing is changed at the anode or in the electrolyte; the latter can be found out by again substituting the platinized platinum for the

lead electrode, when the e. m. f. should have the original value again. He says this method enables one to measure the polarization with an exactness of some thousandths of a volt. The paper is published in the *Zeit. f. Elektrochemie*, August 21st.

**Radio-Activity and the Chemical Atom.**—Although the subject of radio-activity may not properly belong under electrochemistry, there is a conclusion drawn in a recent long paper by RUTHERFORD AND SODDY in the *Phil. Mag.* for September, which may be of some interest here. They made a detailed investigation of the radio-activity of thorium compounds and found it to be accompanied by chemical changes in which new types of matter were being produced. They conclude that radio-activity is a manifestation of "subatomic chemical change," and the hope is expressed that radio-activity "affords the means of obtaining information of the processes occurring within the chemical atom, in the same way as the rotation of the plane of polarization and other physical properties have been used in chemistry for the investigation of the course of molecular change."

**Positive Electrons.**—A long series of experiments have been made by W. WIEN, in which discharges in vacuum tubes were made with perforated cathodes; the positive electrons which travel towards the cathode pass through its perforations and can then be investigated in the same way as the negative electrons in cathode rays, etc. The results which he obtained concerning positive electrons, differ greatly from those formerly obtained for negative electrons, and he believes that certain differences in the color of the fluorescence produced make it possible that chemical influences take part in the phenomenon. For further information see the *Zeit. f. Elektrochemie*, August 14th.

**Electrolysis of Alkaline Chlorides with Platinized-Platinum Anodes.**—It has been known for some time that there is a distinct difference in the process of electrolysis, whether bright or platinized-platinum anodes are used, and, moreover, that the special method of platinizing the platinum also has some influence. FOERSTER AND MUELLER recently made extended researches of this action, which they published in a Bunsen Society paper which is reprinted in the *Zeit. f. Elektrochemie*, July 31st. They used the method of Lummer and Kurlbaum, and found that the average e. m. f. required for the electrolysis of alkaline chlorides is smaller for platinized-platinum anodes by 0.5 volt than for bright platinum. The formation of the chlorate proceeds about the same, although it starts somewhat later at the platinized anode than at the bright platinum, and the platinizing of the anode is of influence only upon the electrolytic processes preceding the formation of the chlorate. They made a very long investigation of the causes of this influence of the platinizing, and found that in the electrolysis of neutral solutions of alkali chlorides with platinized anode, the development of oxygen and the formation of chlorate depend only in a very small degree on the catalytic action of the platinum black, and must, therefore, be caused essentially by electrolytic action. In a great many experiments they found that the substitution of a platinized-platinum anode for a bright platinum plate of equal size, causes a considerable decrease in the voltage required for an electrolytic process, whether the electrolyte is sulphuric acid or sodium hydroxide or sodium chloride. This difference of voltage is not the same in all cases; at a current density of 0.067 ampères per square centimeter, it is, after 8 ampère hours for sulphuric acid 0.46 volt, after 3 ampère hours for sodium hydroxide 0.755 volt, after 10 ampère hours for chloride of sodium 0.82 volt; furthermore, at a current density of 0.017 ampère square centimeter after 11 ampère hours for sulphuric acid it is 0.308 volt, after 10 ampère hours for sodium hydroxide 0.665 volt, and after 11 ampère hours for sodium chloride 0.75 volt. This difference of voltage between the electrolysis with bright and with platinized-platinum anode depends, therefore, upon the nature of the electrolyte and more or less upon the current density, while with sodium hydroxide and sodium chloride it

also changes considerably with the time. The phenomenon is very complicated and the causes do not seem to be clearly understood; the concentration changes at the anode can explain only a very small part of the voltage difference, but it seems that this difference occurs only at the moment when oxygen is developed at the anode. Caspari's overvoltage of oxygen is too small to explain the whole phenomenon, and besides, to call it overvoltage would only be giving a name to the phenomenon without explaining it.

**Hypochlorous Acid.**—On the basis of the measurements of Jakowin on the hydrolysis of chlorine in aqueous solutions, LUTHER, in the *Zeit. f. Elektrochemie*, August 21st, shows that it is possible to predetermine theoretically the electromotive behavior of hypochlorous acid, and makes some critical remarks on a recent experimental investigation of Mueller on the same subject.

**Velocity of Electrolytic Decomposition of Oxalic Acid.**—AKERBERG has found that when a solution of sulphuric acid, containing oxalic acid, is electrolyzed between polished platinum electrodes, the oxalic acid is scarcely decomposed, but that when platinized-platinum electrodes are used it is readily decomposed. He believes that "the decomposition is, therefore, a secondary process, which is catalytically influenced by the platinum black; it is a purely chemical oxidation effected by the electrolytically separated oxygen. In concentrated solution, with low current densities, or at high temperature, the decomposition follows Faraday's law, but in more dilute solution the reaction is carried out by atomic oxygen." A note on his researches will be found in the *Lond. Elec. Eng.*, September 5th.

**Double Anode Process.**—The compound  $(\text{NH}_4)_2 \text{Pb Cl}_4$  may be prepared electrochemically by using simultaneously an anode of carbon and one of lead. This and the general principle of using two different anodes, one soluble and the other inert, which can be done to advantage for many purposes, are described by ELBS in the *Zeit. f. Elektrochemie*, July 31st.

**Cuprous Ions.**—The chemistry of cuprous compounds is discussed by BODLAENDER in the *Zeit. f. Elektrochemie*, July 31st. Among other things he found that the cuprous ions are monatomic, not di-atomic.

## PRIMARY AND SECONDARY BATTERIES.

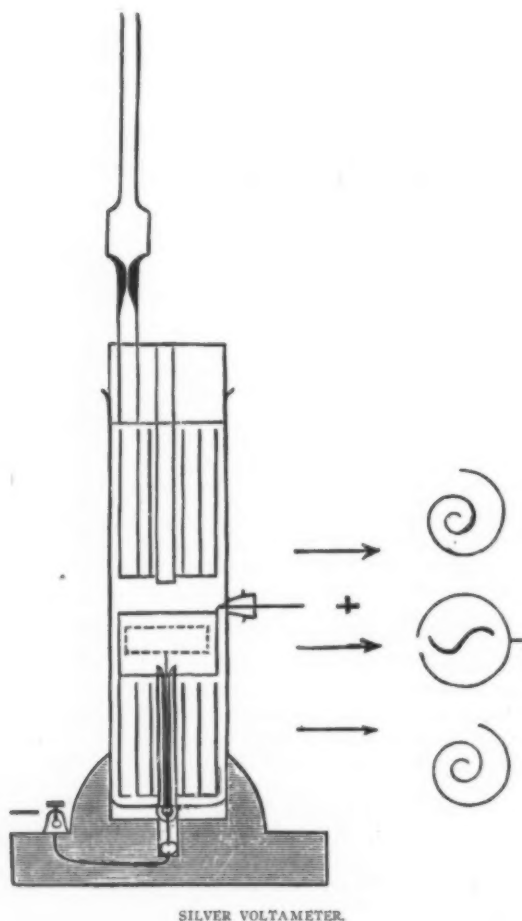
**Accumulator Testing.**—The recent literature on batteries seems to be limited to the publication in the *Zeit. f. Elektrochemie*, August 21st, of the complete paper of LIEBENOW on the use of a third auxiliary electrode in accumulator testing, an abstract of which was noticed in this *Synopsis* last month.

## GENERAL AND MISCELLANEOUS.

**Silver Voltameter.**—The silver voltameter, with all its faults, must be considered a standard instrument until something better has been devised, and meanwhile any of the much-needed improvements in it will be welcomed. In a modification described, with illustrations, by FARUP in the *Zeit. f. Elektrochemie*, August 14th, apparently with the endorsement of Nernst, the process of weighing is simplified without sacrifice of accuracy; it is claimed to be even more accurate for very small currents. The solution consists of about 10 grams of silver nitrate, with about 15 of cyanide of sodium, dissolved to make 100 c. c. of solution, but with this electrolyte it is absolutely necessary to carefully exclude the oxygen of the air, for if it gains to the silver plate it will dissolve considerable of it. The principle of his apparatus consists in keeping the oxygen away from the platinum cathode by means of properly-arranged shields of silver. The adjoining diagram explains the arrangement. A glass tube, forming the vessel, is provided at the bottom with a platinum wire, which is melted through it and leads to a capillary tube, by which the corrugated platinum cathode is supported. The anode is a sheet of silver which surrounds the platinum electrode, the



current being lead into it from the side. Above and below the two electrodes sheets of silver in spiral form are provided for removing the oxygen which is originally in the solution, or diffuses into it during the test. In order to diminish this diffusion as much as possible, the glass is so completely filled with solution that when the rubber stopper is put in, the solution enters the pipette tube which is set into the rubber stopper. The lower end of the platinum wire dips into a drop of mercury to make a good contact. In order to remove all the oxygen originally in the electrolyte, it is necessary to fill the voltameter some time before the circuit is closed. At the end of the test, the platinum electrode is weighed without any other care, except to clean it in distilled water and dry it for a few seconds over a flame.



SILVER VOLTAMETER.

**Goldschmidt Process.**—Although this process is not electrochemical, it is of interest here in that aluminum is the fuel. HOULLEVIQUE, in the *Jour. de Phys.*, May, abstracted in the *Lond. Elec.*, August 8th, describes how he prepared pure iron in this way. He recommends the use of at least 3 kgr. of the mixture of aluminum filings, washed in petroleum essence and dried, and pure sesquioxide of iron, free from sulphur and carefully dried, in excess of about 15 per cent. over the amount required for the chemical reaction, and crucibles lined with magnesia. The addition of 20 per cent. of powdered cryolite to the mass increases the fusibility and raises the yield from 30 to 53 per cent. The slightest trace of sulphur is very obnoxious. There is even greater difficulty in obtaining pure aluminum free from fatty matter.

**Magnetic Separation of Zinc Blende.**—The magnetic separa-

tion of zinc blende from mixed sulphide ores by means of Wetherill magnetic machines, is now being carried on as a regular process at Denver, Colo., according to the *Eng. and Min. Jour.* for August 16th. The ground product is distributed among eight Wifley tables, which separate it into galena-pyrites and pyrites-blende classes, and the latter are then passed over the two Wetherill machines, each having three magnets. These produce a blende product, assaying about 50 per cent. Zn, 10 to 12 Fe and 1 Pb, which is sold to zinc smelters, while the rest is sold to the lead smelters. One per cent. of iron in the blende makes it susceptible to the intense effect of the Wetherill magnets, while pyrite and galena are not affected. The capacity of the zinc mill at Denver is about 40 to 45 tons of crude ore per day.

**Effect of Atmosphere on Aluminum Alloys.**—WILSON, in a British Association paper, describes tests of the electrical conductivity of certain aluminum alloys as affected by exposure to the London atmosphere. The specimens are in the form of wire, 0.126 in (3.2 mm) diameter, supported on a wooden frame; they were exposed on the roof of a building for thirteen months. The position of aluminum in the electrochemical series with respect to the other substances in the analysis is as follows: Al, Mn, Zn, Fe, Ni, Cu, Si. Copper produces corrosion, which increases with its percentage. Nickel alone has considerable effect, but if alloyed with copper the conductivity slightly increased during exposures. The results of the analysis of the different experiments before and after exposure are given in a table. For exposed-light-aluminum alloys it appears that copper should not be used alone; the presence of equal amounts (about 1 per cent.) of nickel and copper certainly reduces conductivity to a small extent, but the gain in mechanical properties and in resistance to corrosion are great. For further details see *Lond. Elec.*, September 19th.

**Electro Analysis.**—In the *Zeit. f. Elektrochemie*, June 19th, HANAMAN gives an illustrated description of an apparatus for this purpose, in which all the different devices and accessories are combined.

The methods of Bindschedler for the electrolytic estimation of mercury, that of Brunck for the estimation of bismuth, and that of Moltke-Hansen for the separation of lead and manganese, are described by ARTH in *L'Eclairage Elec.*, August 2d.

**Course in Physical Chemistry.**—The course at the University of Bonn is described with illustrations by LOEB and RIMBACH in the *Zeit. f. Elektrochemie*, July 10th.

## CURRENT NOTES.

**American Electrochemical Society.**—The next meeting of the American Electrochemical Society will probably be held in New York City in the spring of 1903; this will be the annual business meeting, with election of officers, etc. We understand that it has been suggested to hold, in the summer of 1903, a joint meeting with the American Institute of Electrical Engineers, at a place near Sault Ste. Marie, Ont. The idea has much to be recommended, but no official steps have yet been taken. From another side it has been suggested that a joint meeting of the American Chemical Society and of the American Electrochemical Society should be arranged. There is no doubt that such meetings would further the interests of electrochemistry, and the social intercourse between electrochemists and their colleagues from the purely electrical and the purely chemical profession would be of value to all concerned. We hope, therefore, that these suggestions which have so far been made only by individual members will be received with favor by the councils of the three societies, and that they may be carried into effect.

**American Aluminum Association.**—The second annual meeting of the American Aluminum Association was held at Pittsburgh, Pa., September 18th, 19th and 20th. More than 90 per cent. of the entire aluminum interests of America were represented by delegates. Matters of business relating to the improvement of trade conditions were discussed. A paper on the future of aluminum industry was presented by Dr. Joseph W. Richards. Officers for the ensuing year were elected, Mr. Joseph A. Steinmetz, of Philadelphia, president; Mr. Wagner, of Sydney, Ohio, vice-president; Mr. Palmer F. Langdon, of New York, secretary and treasurer. Various committees were appointed to formulate trade relations and to insure the proper and correct application of the metal to approved uses. It was determined to be represented at the Louisiana Purchase Exposition at St. Louis in 1904 by a large and comprehensive associated display, showing the history of the metal from its discovery, its ores, treatment, processes of reduction, and applications of the metal, as well as a complete display of all articles thus far successfully made of aluminum. The Metallurgical Committee, who will have this development in hand, is composed of Dr. Joseph W. Richards, who has been ever identified with aluminum and its history and metallurgy; Mr. Arthur V. Davis, general manager of the Pittsburgh Reduction Co., the largest producing company of aluminum in the world, and Mr. Joseph A. Steinmetz, who has been for some ten years closely associated with the metal and its fabrication and general application in the arts and sciences.

**Mineral Products of the United States.**—The United States Geological Survey has published a very interesting statistical table showing the mineral outputs of the United States in the ten years, 1892 to 1901. Among the metallic products we find aluminum, the output of which in 1892 was 259,885 pounds, with a value of \$172,824, and in 1901, 7,150,000 pounds, with a value of \$2,238,000; that is, the output of aluminum in 1901 was more than 27 times greater than in 1892, while the value per pound in 1901 was less than one-half of that of 1892. At the end of this table interesting statistics of the total value of the mineral products since 1880 are given: \$369,319,000 in 1880; \$619,648,925 in 1890, and \$1,092,224,380 in 1901. The table has been compiled by Director Charles D. Walcott, under the supervision of Dr. David T. Day.

## CORRESPONDENCE.

### THE ELECTROMOTIVE FORCE OF THE DANIELL CELL

To the Editor of the *Electrochemical Industry*:

SIR:—Professor Carhart is quoted in your September issue, page 9, in his "Contributions to the Theory of Concentration Cells," as saying that the increase of the electromotive force of the Daniell cell with the increase of density of the copper sulphate solution, and its decrease with increase of density of the zinc sulphate solution, is clearly explained by his thermo-electric theory, and that "the only other explanation of this fact ever given is based on osmotic pressure."

Without going into any criticism of the thermo-electric theory of concentration cells (which theory the writer is not yet ready to accept as explaining the *origin* of their electromotive force), the writer wishes to call attention to the fact that another explanation of the Daniell cell phenomenon is to be found, which is based neither on a thermo-electric theory, nor on the theory of osmotic pressure, but on a few well-demonstrated *experimental facts*.

We all agree that the difference in the heats of formation of zinc sulphate and copper sulphate, in aqueous solution, is the chief, if not the only, source of the electromotive force of the cell in question. But, these heats of formation vary with the concentrations of the solutions formed, both of them increase as the solutions formed are the more dilute. Therefore, if the copper is deposited from a more concentrated solu-

tion, in which the formation heat of the copper salt is less, the value of the heat energy transformed in the cell is increased, and its electromotive force correspondingly *increased*. If, on the other hand, the zinc is dissolved into a more concentrated solution, the formation heat of the zinc salt is less, and the electromotive force of the combination is correspondingly *decreased*.

Similar thermochemical considerations, of the varying solution heats of sulphuric acid of varying dilutions, are applicable to explain part of the variations of electromotive force of the lead accumulator.

These thermochemical data are such well-established facts, and their applicability to explain the variations in the Daniell cell referred to, as well as to concentration cells in general, so patent and necessary, that it seems that the statement of Prof. Carhart must be revised so as to take these into account.

JOSEPH W. RICHARDS.

Lehigh University.

## BOOK REVIEWS.

MONOGRAPHIEN ÜBER ANGEWANDTE ELEKTROCHEMIE. I. Band: Die Elektrolyse des Wassers. Von Viktor Engelhardt. Halle: Wilhelm Knapp, 1902. 117 pages, with 90 illustrations and 15 tables. Price, 5 marks.

This is the first volume of a series of monographs, to be published at regular intervals on special subjects of applied electrochemistry. Each volume is to give a full and detailed report of the development and present state of the subject treated in it. Viktor Engelhardt, the chief chemist of the Siemens & Halske Co. in Vienna, will be the editor of the whole series. He is also the author of the first volume which deals with the electrolysis of water, its methods and its use.

The author first gives some historical notes on early investigations, and notices the physical and chemical constants which enter into the problem. He then describes in detail and at length the different methods which have been devised for the electrolysis of water. The methods for producing oxygen and hydrogen separately are divided into three classes. In the first one porous diaphragms of non-conducting material are used; in this class are the processes of d'Arsonval, Latchinoff, Ducretet, Renard, Delmard, Bell, Schmidt. In the second class solid, non-porous and non-conducting diaphragms are used which, of course, do not separate the whole electrolyte into entirely separate parts, as globes or bells of non-conducting material are placed around the electrodes. Here we have some well-known laboratory apparatus, and also the methods of Ascherl, Schoop, Hazard-Flamard, Verney. The third class is similar to the second, but conducting non-porous diaphragms are used and the e. m. f. is kept low enough to prevent a diaphragm from acting as cathode on one side and as anode on the other side. In this class are described the methods of Garuti, Siemens Bros. and Obach, Schuckert & Co. All these methods are described in detail with many illustrations. The author then describes the various voltmeters in which oxygen and hydrogen are produced together, and notices the attempts which have been made to obtain pure oxygen by electrolysis without the use of diaphragms; this may, for instance, be done by using a depolarizing cathode which is reduced during electrolysis. This chapter is concluded by a table which gives a good review of the different patented processes and their particular features.

In the second half of the book the author discusses the commercial aspect of the problem and the commercial use of the products of the electrolysis of water. He gives data on the cost of the gases when produced by the different processes and then discusses the following commercial applications: oxygen and hydrogen together for producing high temperatures, for lighting, for blasting; hydrogen for filling balloons, for soldering and for lighting. The book is concluded by an appendix containing several tables, and by an index giving the names of authors and inventors.

THE COPPER HANDBOOK. Vol. II. Compiled and published by Horace J. Stevens, Houghton, Mich. Paper, \$1; buckram, \$2; full morocco, \$3.

This handbook is designed chiefly for business men and others who are financially interested in copper mines.

For such, as well as for the general scientific public, the book is valuable, for in it are compiled many facts about the history, metallurgy, mining and uses of copper.

Almost every mine in the world receives a short notice, and the great mines of Montana, Arizona and Michigan are the subject of short historical sketches. As the information on which these sketches are based is semi-official, it can be scarcely doubted that it is fairly reliable. But the outputs of some of the smaller mines is rather an estimate of what might be done under most favorable conditions than a statement of past production.

The chapter on general copper statistics is especially valuable, and contains many useful tables, as, for instance, a table converting London price of copper expressed in pounds sterling per long ton, to cents per pound—the American units. In this connection, it is well to note that there are four tons used in weighing copper and its ores. Troy, avoirdupois, metric and long tons. This certainly throws a burden on the statistician of copper.

For the class for which this book is written the book certainly is a useful compendium and a handy book to have near at hand.

### BOOKS RECEIVED.

MONOGRAPHIEN UEBER ANGEWANDTE ELEKTROCHEMIE. Vol. II. Die Gewinnung des Aluminiums. By Adolphe Minet. Translated into German by Dr. Emil Abel. Halle: Wilhelm Knapp. 129 pages, with 57 illustrations and 15 tables. Price, marks 7.

MONOGRAPHIEN UEBER ANGEWANDTE ELEKTROCHEMIE. Vol. III. Die Darstellung des Chroms und seiner Verbindungen mit Hilfe des elektrischen Stromes. By Dr. Max LeBlanc. Halle: Wilhelm Knapp. 110 pages. Price, marks 6.

EINFUEHRUNG IN DIE ELEKTROCHEMIE. Nach der elektrolitischen Dissociationstheorie. By Peter Gerdes. Halle: Wilhelm Knapp. 124 pages, with 48 illustrations.

THE MINERAL INDUSTRY. Its Statistics, Technology and Trade in the United States and other countries to the end of 1901. Founded by Richard P. Rothwell. Edited by Joseph Struthers, Ph. D. Vol. X. New York: The Engineering and Mining Journal. 920 pages. Price \$5.

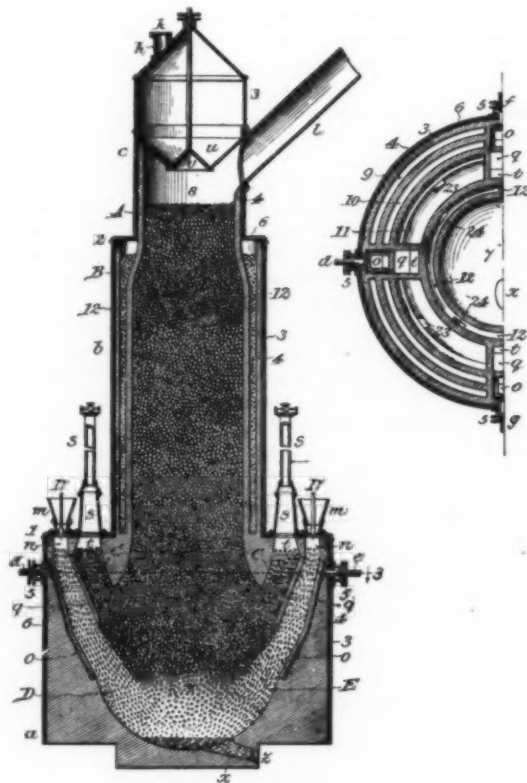
THE OPTICAL ROTATING POWER OF ORGANIC SUBSTANCES AND ITS PRACTICAL APPLICATIONS. By Dr. Hans Landolt, assisted by Dr. O. Schoenrock, Dr. P. Lindner, Dr. F. Schuett, Dr. L. Berndt and Dr. T. Posner. Second edition. Authorized English translation with additions by Dr. John H. Long. 751 pages with many illustrations. Easton, Pa.: The Chemical Publishing Co. Price, bound in cloth, \$7.50.

### A CLOSED CONTINUOUS-WORKING ELECTRIC FURNACE.

The adjoining illustrations represent a type of electric furnace invented by E. R. Taylor, Penn Yan, N. Y., and primarily intended and used at present for the manufacture of carbon bisulphide. The principle of this latest type permits, however, a much wider application and the inventor states that he will soon apply it to the manufacture of other chemicals.

One of the distinguishing features in the latest type is the electrodes, which are self-renewing and feed themselves by gravity. As shown in the cut the furnace is vertical shaped, and on the inside at the bottom is rounded. The inlet pipes

are designated by *mm*, *ss* and *h*. There are the sources of current at *d* and *e*, and connected to them on the inside are trough-shaped conduits which extend towards the bottom of the furnace. The lower part of the conduits are constructed at an angle so that the descent of the fragmentary matter is retarded and thrown inwardly towards the middle of the working chamber, where the heat zone is. The electrodes, feeding themselves by gravity, descend into the bottom of the working chamber from the outlet of the conduits *o*, and gradually come close together at the bottom. They are naturally thinnest where they come together, thus affording the necessary resistance, and converting the electricity into heat. The heat zone is thus located at the bottom. There are four



TAYLOR ELECTRIC FURNACE.

electrodes, which are diametrically opposite each other, and are situated 90° from each other.

The fragmentary carbon is introduced at *ss* or at *h*, and the crushed sulphur at *mm* and corresponding points around the furnace. The sulphur is thrown towards the bottom of the working chamber and thus it is fused at the same time with the carbon. The vapors ascend up through the furnace through the pipe *i* into condensers, and are there liquefied. At the bottom of the furnace is a tap-hole *x*, where the residue may be taken out.

The furnace is continual in its operation, and at no time does the current have to be shut off to insert fresh material.

The manufacture of carbon bisulphide is carried on extensively at this plant, and there is a good market for it. Carbon bisulphide is used in large quantities for exterminating the insects and small animals which destroy thousands of dollars' worth of grain annually; for this purpose no exterminator is said to have given as much satisfaction as carbon bisulphide. It is also used for other purposes, among which may be mentioned the following: As a disinfectant; for preserving perish-



able articles; with chloride of sulphur for vulcanizing india rubber; for extracting oil from seeds, wool, bones, etc. Carbon bisulphide evaporates quickly, and the fumes, which are heavy, descend into the grain, cracks and holes, and effectually destroy all animal life. Attention has recently been called to important new applications in London *Engineering*, where, it is said, that the economy of cyanide recovery processes in coal-gas manufacture is threatened by a new process depending on the use for the same purpose of carbon bisulphide.

### A NEW STORAGE BATTERY.

An interesting cerium storage battery has recently been devised by Dr. Auer von Welsbach, the famous Austrian chemist and inventor of the incandescent gas-light mantle and of the osmium electric incandescent lamp. It may be called a cerium battery because it is the use of cerium salts which is its peculiar novel feature. To characterize the cell in a general way, it may be said to be of the type of the Bunsen battery. It is a double fluid cell with diaphragm. The positive plate (the plate where the current leaves the cell during discharge) is inert; the negative plate is amalgamated zinc; the electrolyte at the negative plate is

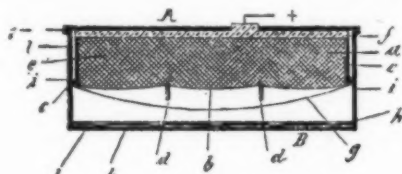


FIG. 1.—WELSCHACH STORAGE BATTERY.

zinc sulphate. So far is the construction the same as that of the Bunsen cell. But while in the latter strong nitric acid is used as the depolarizer at the positive plate, Auer von Welsbach uses a specially prepared saturated solution of a double salt of sulphates of cerium and zinc; as positive plate he uses a finely divided fabric of elastic graphitized carbon. During discharge zinc dissolves and ceric sulphate is reduced to cerous sulphate. During charge zinc is deposited upon the electrode, and at the other end cerous sulphate is oxidized to ceric sulphate.

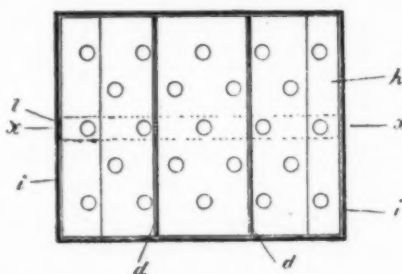


FIG. 2.—WELSCHACH STORAGE BATTERY.

The construction of the battery is shown in the adjoining diagrams. Fig. 1 shows a vertical section, Fig. 2 a horizontal section. The negative plate is a perforated sheet of amalgamated zinc *h*, 1 mm. thick, covered with mercury; it is in contact with the amalgamated iron strip *l*. The positive electrode consists of a fabric or of foils of elastic graphitized carbon *e*, which is contained in a celluloid frame *c*, which is open at the upper and at the lower side. At the upper side a graphite plate *f* is pressed slightly against the fine graphite fabric—*d* and *d* are small cross pieces which hold the graphite fabric in position. At the lower rim of the celluloid frame the arched diaphragm *g* is attached; it has to prevent any pieces of carbon from falling down upon the zinc plate; it also prevents

mixing of the electrolytes, and causes any bubbles of hydrogen gas which arise, to escape upwards along the sides.

To set up the battery, the celluloid frame containing the graphite fabric is placed into the box containing the negative plate; the upper part with the graphite fabric is then filled with the cerium electrolyte. If the battery is used for stationary purposes, stirring is necessary. For service on automobiles it is claimed that the vibrations of the carriage are sufficient. The cell is said to be best adapted to purposes when the discharge follows the charge immediately.

The e. m. f. of the battery is claimed to be higher than that of the lead accumulator, the capacity, per unit of weight, is said to be several times that of the lead accumulator.

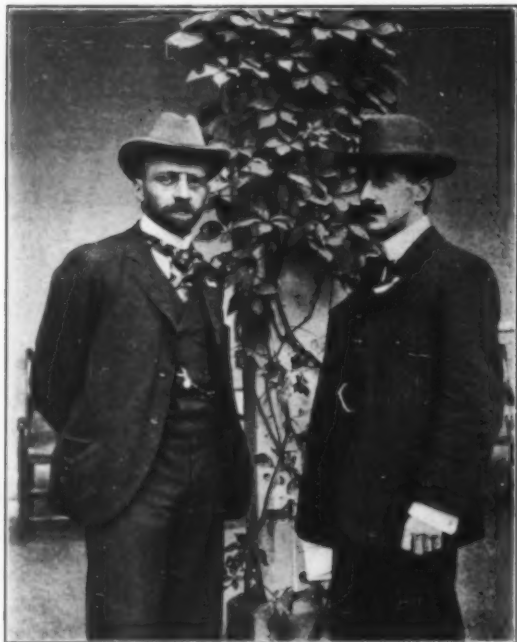
### PERSONAL.

The following is the complete alphabetical list of the members and guests who registered at the Niagara Falls meeting of the American Electrochemical Society:

E. G. Acheson, Chas. E. Acker, Niagara Falls, N. Y.; W. D. Bancroft, Ithaca, N. Y.; H. T. Barnes, Montreal, Que.; Chas. B. Barton, Berlin, N. H.; Mrs. J. Warner Batt, Albany, N. Y.; Geo. H. Baynes, Jr., Ithaca, N. Y.; F. M. Becket, Niagara Falls, N. Y.; C. H. Beirbaum, Buffalo, N. Y.; H. S. Blackmore, Mt. Vernon, N. Y.; Earl Blough, Ithaca, N. Y.; Chas. S. Bradley, Geo. F. Brindley, Niagara Falls, N. Y.; Oliver W. Brown, Bloomington, Ind.; Wm. Hand Browne, Jr., New York City; C. F. Burgess, Madison, Wis.; Miss Burnell, Charlotte, N. C.; Eugene A. Byrnes, Washington, D. C.; Henry S. Carhart, Ann Arbor, Mich.; H. R. Carveth, Ithaca, N. Y.; H. B. Coho, New York City; Chas. W. Coit, C. A. Collins, 2d, Niagara Falls, N. Y.; Miss L. Conord, Miss A. Conord, West Hoboken, N. J.; Alfred H. Cowles, Cleveland, Ohio; G. E. Cox, Niagara Falls, N. Y.; F. B. Crocker, New York City; E. A. Deeds, Niagara Falls, N. Y.; L. C. Dodd, Buffalo, N. Y.; Norman Dodge, Philadelphia, Pa.; W. F. Doerflinger, Niagara Falls, N. Y.; C. S. Doggett, E. Chicago, Ind.; Sarah R. A. Dolly, Rochester, N. Y.; Wm. H. Dopp, Buffalo, N. Y.; Chas. A. Doremus, Gustav Drobegg, New York City; Henry H. Durham, G. W. Englehart, R. W. English, Buffalo, N. Y.; Francis A. J. Fitzgerald, Niagara Falls, N. Y.; L. H. Flanders, Pittsburg, Pa.; Geo. W. Fletcher, Brooklyn, N. Y.; Francis Forbes, New York City; S. P. Franchot, Niagara Falls, N. Y.; Oliver P. Fritts, Denver, Colo.; Austin Fritchle, Mrs. Austin Fritchle, Tuscaloosa, Ala.; Wm. C. Geer, Ithaca, N. Y.; A. E. Gibbs, W. T. Gibbs, Niagara Falls, N. Y.; W. E. Goldsborough, St. Louis, Mo.; Chas. J. Greenstreet, Ford City, Pa.; F. Haber, Karlsruhe, Germany; Max M. Haff, C. M. Hall, S. F. Hall, Niagara Falls, N. Y.; C. Hambuechen, Madison, Wis.; Wm. D. Harris, Philadelphia, Pa.; Edward Hart, Easton, Pa.; Walter H. Hart, Philadelphia, Pa.; J. C. Heckman, Buffalo, N. Y.; Carl Hering, Philadelphia, Pa.; Aldus C. Higgins, Worcester, Mass.; Wm. Hoskins, Chicago, Ill.; G. M. Howard, Philadelphia, Pa.; Henry Howard, Brookline, Mass.; R. S. Hutton, Manchester, Eng.; Alois von Isakovics, New York City; Geo. N. Jeppson, Worcester, Mass.; Woolsey McA. Johnson, New Brighton, N. Y.; Louis Kahlenberg, Madison, Wis.; N. S. Keith, New York City; R. N. Kofoid, Buffalo, N. Y.; A. S. Krebs, Wilmington, Del.; A. A. Kundson, New York City; H. S. Lamdale, Buffalo, N. Y.; A. B. Larchar, Great Works, Me.; Miss C. A. Lee, Rochester, N. Y.; P. M. Lincoln, Pittsburg, Pa.; C. F. Lorenz, Iowa City, Iowa; D. R. Lovejoy, Niagara Falls, N. Y.; F. J. Machalske, Chicago, Ill.; Albert Marsh, Niagara Falls, N. Y.; A. B. Marvin, Jr., Washington, D. C.; Wm. O. Mathews, Mrs. W. O. Mathews, Cleveland, Ohio; F. G. Maywald, Brooklyn, N. Y.; Jacob J. McConnell, Colwyn, Pa.; J. A. McKittrick, Schenectady, N. Y.; James McMahon, Niagara Falls, N. Y.; John A. Miller, Buffalo, N. Y.; W. L. Miller, Toronto, Ont.; Max Moran, Niagara Falls, N. Y.; Richard F. Morgan, Buffalo, N. Y.; Henry G. Morris, Philadelphia, Pa.; H. B. Moses, Buffalo, N. Y.; E. H. Mullin, New York City; R. J. Nunn, Savannah, Ga.; Frank M. Oliver, Philadelphia, Pa.; J. G. O'Neill, Niagara Falls, N. Y.; Louis A. Parsons, Baltimore, Md.; Geo. W. Patterson, Ann Arbor, Mich.; Harold C. Pease, Buffalo, N. Y.; Frank C. Perkins, Buffalo, N. Y.; O. W. Pickering, Cleveland, Ohio; Herbert W. Pool, Philadelphia, Pa.; Henry Noel Potter, New York City; E. P. Price, Niagara Falls, N. Y.; S. Reber, Washington, D. C.; C. J. Reed, Philadelphia, Pa.; Arvid Reuterdaahl, Mrs. Arvid Reuterdaahl, Providence, R. I.; Joseph W. Richards, Wm. Richards, Bethlehem, Pa.; W. A. Robbins, Mrs. W. A. Robbins, Camden, N. J.; J. C. Roberts, A. G. Rodgers, Niagara Falls, N. Y.; Hugh Rodman, E. F. Roeber, C. W. Roepper, Philadelphia, Pa.; T. R. Rosebrugh, Toronto, Ont.; S. H. Ross, P. G. Salom, Philadelphia, Pa.; Barthold E. Schlesinger, Boston, Mass.; F. E. Schmitt, New York City; Geo. O. Seward, Holcomb Rock, Va.; Samuel Sheldon, Brooklyn, N. Y.; E. S. Shepard, Ithaca, N. Y.; John E. Shero, Niagara Falls, N. Y.; A. W. Smith, Cleveland, Ohio; Edward W. Smith, Philadelphia, Pa.; W. O. Snelling, Washington, D. C.; C. C. Speiden, New York City; Elmer A. Sperry, Mrs. C. A. Sperry, Cleveland, Ohio; Thos. E.

Steen, Niagara Falls, N. Y.; Thomas G. Steward, Washington, D. C.; Walter P. Taggart, Philadelphia, Pa.; Edward R. Taylor, Miss Edith Taylor, Mrs. E. R. Taylor, Chas. E. Taylor, Penn Yan, N. Y.; C. W. Thomas, Mrs. C. W. Thomas, Hutley, N. J.; Geo. H. Thornton, Buffalo, N. Y.; Erik W. Tillberg, Worcester, Mass.; F. J. Tone, Niagara Falls, N. Y.; C. P. Townsend, Washington, D. C.; Geo. M. Turner, Buffalo, N. Y.; W. H. Walker, Boston, Mass.; W. D. Weaver, New York City; A. T. Weightman, Samuel Weil, Niagara Falls, N. Y.; G. G. Wiechmann, Brooklyn, N. Y.; Ray Hill White, R. A. Witherspoon, Niagara Falls, N. Y.; S. E. Whiting, Cambridge, Mass.; W. R. Whitney, Boston, Mass.; Wm. M. Whitten, Niagara Falls, N. Y.; Chas. C. Wright, Washington, D. C.; O. G. Victor, Buffalo, N. Y.; H. N. Yates, North Tonawanda, N. Y.

We reproduce herewith a photograph of the foreign guests of the American Electrochemical Society at the Niagara Falls meeting, Prof. F. Haber, of the Institute of Technology, of Karlsruhe, Germany, and Mr. R. S. Hutton, of Owens College,



F. HABER AND R. S. HUTTON.

Manchester, England. We are indebted for this picture to Mr. Walter R. Taggart, of the University of Pennsylvania, who took the snap-shot on the veranda of the International Hotel at Niagara Falls. Mr. Hutton has meanwhile returned to England. Professor Haber is in the West, and will sail for Germany in November.

MR. TITUS ULKE has returned to Sault Ste. Marie from an extended trip to the West.

#### OBITUARY.

SIR FREDERICK ABEL died suddenly on September 6th, at his residence in Whitehall Court, London. He has been best known as the chemist to the British War Office, from 1854 to 1888. In this capacity he conducted the researches which led to the adoption of the smokeless powder or cordite. He took great interest in technical education and research, and was also intimately connected with the electrical profession, being in 1877 the president of the British Institution of Electrical Engineers. He also served at various times as president of the Chemical Society, the Institute of Chemistry, the Society of Chemical Industry, and the Iron and Steel Institute, and was a fellow of the Royal Society. Among his numerous writings was a treatise, in 1884, on electricity applied to explosive purposes. He was born in 1827 and entered in 1845 the Royal College of Chemistry, where he obtained his chemical training under the famous German chemist, A. W. von Hofmann.

#### INDUSTRIAL NOTES.

MR. MARCUS RUTHENBERG, Philadelphia, is contemplating installing a very large reduction plant for the Pennsylvania Steel Co.

MR. J. L. MALM, Marysville, Mont., is installing an electrical precipitation plant in connection with cyaniding operations, the only one in the State of Montana.

A FIRM in California is said to be introducing an electrolytic-alkali process, the first at the Pacific Coast.

We have received from President A. E. Newton, of the Cutter Electrical and Mfg. Co., Philadelphia, their recently-issued most-handsome book, "ITE Switchboard Practice." It is one of the best examples of the modern type of trade catalogues, print and illustrations being beautiful. The principle of the automatic circuit breaker and its application to all the various purposes for which it may be used are discussed, the descriptions being profusely illustrated. Of special interest to our readers will be the chapter on the use of the circuit breaker in connection with storage batteries. The book also contains chapters on measuring instruments (Keystone instruments) and on switchboard construction.

**WATER-POWER.**—The firm of Pepper & Register, Philadelphia engineers and general contractors, are developing a large water-power on the St. Lawrence River, about 18 miles from Ogdensburg, N. Y. The complete hydraulic development is to be installed at once, and the electrical power to be installed in increments when sold to consumers. The total development is for 34,500 mechanical horse-power. The power plant is admirably located. No inland port could have greater advantages for shipping. The region of the Great Lakes, with its resources and enormous trade, and the entire basin of the St. Lawrence are tributary to it, and bring the development in close touch with the chief centers of the American continent. The plans proposed by Pepper & Register are for extensive piers and wharves on the St. Lawrence River. The plans also contemplate excellent railroad connections. By the construction of a short road to Ogdensburg, direct connection is made with the New York Central and Hudson River Railroad, the Grand Trunk Railroad, the Rome, Ogdensburg and Watertown and the Rutland Railroads. The place is admirably suited for electrochemical industries to settle down. The natural advantages for construction of a larger power plant at Waddington are such that the cost of development will be low. Pepper & Register are prepared to make contracts for the sale of power, to be delivered within twelve months, which will be as soon as it would be possible for industrial enterprises to complete their buildings and establishments ready to receive this power.

#### DIGEST OF U. S. PATENTS PRIOR TO JULY, 1902.

Compiled by Byrnes & Townsend, Patent Lawyers,  
National Union Building, Washington, D. C.

*This digest of electrochemical United States patents prior to July, 1902, will be one by classes, setting out for comparison in each class those devices which have the same object, or those methods which seek the same results. In each class the patents will be arranged chronologically. The digest will be complete in the sense of covering every point which is touched upon in the original specification.*

ELECTROLYSIS OF SODIUM CHLORIDE WITH MERCURY CATHODES.—  
(CONCLUDED.)

578,457. March 9, 1897; C. Kellner, Vienna, Austria-Hungary.  
Mercury cathode flows in helical path under the anode.

Withdrawn into decomposition vessel, where amalgam flows over inclined riffle in ammonium nitrate solution, forming ammonia and caustic soda.

Cathode in this vessel and current generated is used as desired, of his  
Mer. <sup>or his</sup> coupled and return.

586,635. July 20, 1897; H. C. F. Stormer, Christiania, Norway.  
Amalgam-washing apparatus.

Amalgam lifted in perforated tray and flows down through water over rods of glass, ebonite or carbon.

586,729. July 20, 1897; C. Kellner, Vienna, Austria-Hungary.  
Mercury cathode descends in helical or zigzag channel, passing repeatedly through openings in a non-conducting partition, and coming alternately into contact with the electrolyte and the oxidizing solution.

In latter solution is short circuited with metal-containing vessel.

Vertical tubular carbon anode serves as feed tube for sodium chloride in one modification.

588,276. August 17, 1897; C. Kellner, Vienna, Austria-Hungary.

Mercury containing sodium withdrawn from decomposing cells through rocking box to break connections, and passed through a series of oxidizing cells, between which electrical connections are likewise broken.

Each oxidizing cell contains a cathode to which amalgam acts as anode. These cells are electrically connected in series, whereby is obtained a current of potential sufficiently high to be employed in decomposing cells.

600,211. March 8, 1898; H. C. F. Stormer, Christiania, Norway.

Reduces decomposition of water of electrolyte by separated sodium, by gently agitating the mercury cathode, whereby portions of the superposed amalgam film are continuously dissolved by, or diffused throughout, the body of the mercury.

Uses vertically reciprocating perforated plates or horizontally reciprocating rifled plate.

603,300. August 2, 1898; B. E. F. Rhodin, Sault Ste. Marie, Can.

Modification of Rosenbaum's device (546,348).

Mercury cathode in circular cell having radial ribs.

Anodes in circular bell having plurality of open-ended tubes projecting into mercury.

As anode cell revolves, amalgam formed in tubes comes in contact with water in external cell.

614,353. November 15, 1898; H. C. F. Stormer, Christiania, Norway.

Amalgam-washing device; amalgam drawn off into washing vessel, containing a skeleton drum, formed of side discs connected by a series of rods. As drum revolves, amalgam is carried up by rods and exposed in thin film to solvent.

May increase surface by placing open-mesh metal cloth around rods or weaving it through them.

627,193. June 20, 1899; J. F. Kelly, Pittsfield, Mass.

Amalgam-washing device. Amalgam circulates through chamber having carbon sides. Carbon sides, in electrical contact with amalgam, hasten oxidation and do not affect color of caustic.

631,468. August 22, 1889; C. Kellner, Vienna, Austria-Hungary.

Electrode in oxidizing cell, and a short circuit between amalgam and such electrode, such short circuit constituting a part of the return line of the main circuit.

In this construction the current derived from oxidation of the sodium is opposed to main current, and oxidation of mercury is avoided.

636,234. November 7, 1899; E. Baker, Winchester, Mass.

Mercury cathode flows in tortuous channel between low partitions which support the anodes. The discharge pipe is

U shaped, and rises outside the cell to such height above the mercury within as will counterbalance the electrolyte, thus forming effective seal.

Oxidizing cell contains relatively deep layer of amalgam, which is thereby permitted to stratify. Flow of lighter amalgam is further retarded by inclined dams, imperforate at top.

645,055. March 13, 1900; H. S. Anderson, Springfield, Mass.

Mercury has tortuous flow in both decomposing and oxidizing cells, but latter is at higher level than former and amalgam is forced up by centrifugal pump. The barrel of this pump is perforated at such level that, in case pump works too rapidly, mercury will overflow, but electrolyte will not be pumped into oxidizing cell.

646,313. March 27, 1900; B. E. F. Rhodin, Sault Ste. Marie, Can.

Apparatus generally similar to 608,300, except that anode tubes are closed at upper end by inclined diaphragms, and anodes consist of crude copper in sodium sulphate solution.


Copper sulphate formed in anode compartment and sodium amalgam at cathode.

Ribs under mercury are inclined to radii, whereby the motion of anode bell causes amalgam to work outward toward periphery. After oxidation occurs the heavier mercury flows back toward center and under anodes.

652,761. July 3, 1900; J. B. Entz, Philadelphia, Pa.

In cell of Castner type affects circulations of the mercury by means of magnetic field.

659,655. October 16, 1900; E. Edser, London, Eng.

Cell divided into two or more compartments by one or more vertical partitions consisting of superposed V-shaped troughs of glass, or metal partly covered with mica, each trough containing sufficient mercury to cover the lower edge of the trough above. Brine electrolyzed in one compartment by a current passing from a carbon anode to the mercury in the troughs. The deposited sodium diffuses through the mercury to the other side of the partition, where it is oxidized by water, which fills the second compartment. The electrolyzing compartment is covered by a removable hood with outlet for chlorine, the lower edge of which extends into a mercury seal, a layer of vaseline or oil on the mercury protecting it from chlorine. To facilitate oxidation of sodium, places iron wire-gauze cathode in water compartment, and either short circuits it to mercury in troughs or connects terminals of dynamo to the carbon anode and iron cathode, the mercury acting as a bipolar electrode. In the latter case, interposes a resistance wire between the mercury and iron cathode to direct more current through the brine than the water. The vertical partition may be flat or annular. May employ a horizontal or an inclined partition with troughs of  section, the lower edge of each dipping into mercury held in the next.

661,188. November 6, 1900; A. Nettl, Prague, Austria.

Cathode consists of a number of fine streams of mercury, flowing through holes or nozzles in the bottom of a supply vessel down through the brine, between carbon anodes. The sodium amalgam collecting at the bottom of the cell is protected from the brine by a layer of chloroform or carbon disulphide, lying upon the amalgam. Jets of mercury may be forced through the brine from below, in any desired direction, instead of allowing it to drop vertically.

673,754. May 7, 1901; G. and G. W. Bell, Liverpool, Eng.

General construction that of Castner cell, with two electrolyzing chambers and an intermediate oxidizing chamber. Causes the mercury to reciprocate between the chambers by first closing the chlorine outlet of the electrolyzing chamber, until the pressure of accumulated chlorine, acting on surface of brine, forces amalgam into oxidizing chamber, and, then, after a suitable interval for oxidation, opening chlorine outlet and allowing depleted mercury to flow back. Chlorine outlet may



be automatically controlled by a hydraulic timing device, or an electric motor meter in main circuit, or clockwork. May also force amalgam into oxidizing chamber by automatically raising level of brine in electrolyzing chamber, and then lowering level to permit mercury to flow back.

674,927. May 28, 1901; M. Mauran, Niagara Falls, N. Y.

Cathode for the oxidizing chamber of Castner cell used at Niagara, consisting of a series of parallel wrought-iron bars connected at the ends by cast-lead blocks.

674,930. May 28, 1901; M. Mauran, Niagara Falls, N. Y.

Adjustable knife-edge supports for Castner cell used at Niagara, and ball-and-socket connection to pitman which rocks cell.

674,931 and 674,933. May 28, 1901; M. Mauran, Niagara Falls, N. Y.

Anodes for the Castner cells used at Niagara, consisting of carbon bars having horizontal flanges at each side to extend over the mercury cathode, the flanges being slitted to facilitate escape of chlorine. Terminals consist of copper-plated carbon plugs, driven into recesses in upper portion of anode and connected by zigzag lead strips soldered to plugs. Upper portions of anodes extend through slots in cell cover and are surrounded by Portland cement.

674,932. May 28, 1901; M. Mauran, Niagara Falls, N. Y.

T-shaped pipe for removing gas from tilting Castner cell used at Niagara. Two branches of pipe extend into two gas-producing chambers and the third leads into gas main.

674,934. May 28, 1901; M. Mauran, Niagara Falls, N. Y.

Cathode for oxidizing chamber of Castner cell used at Niagara, consisting of a series of thin, parallel wrought-iron bars, each bent upward at right angles at both ends, with the free ends again bent at right angles to give horizontal terminals, which extend out of the cell.

678,851. July 23, 1901; H. S. Anderson, Springfield, Mass.

Interposes between mercury cathode and bottom of cell a thin, porous layer of pipe clay or pumice stone, which becomes saturated with brine, so that sodium is deposited on lower as well as upper surface of mercury. Porous layer may have a ridge extending into brine, with vertical openings to facilitate passage of brine into portions beneath mercury.

679,476. July 30, 1901; J. F. Kelly, Pittsfield, Mass.

Movable outer vessel contains layer of mercury and water. Electrolyzing chamber consists of fixed box with open bottom, within and extending down into mercury in outer vessel. Outer vessel reciprocated to bring new surfaces of mercury beneath brine and expose amalgam to water.

679,477. July 30, 1901; J. W. Kynaston, Liverpool, Eng.

Cathode consists of thin horizontal layers of mercury held in superposed non-conducting trays. Openings at alternate ends of trays cause mercury fed into upper tray to travel back and forth through series, amalgam escaping from bottom tray. Depth of mercury in each tray determined by a transverse ridge near discharge opening. Terminal wires touch mercury in each tray. Carbon anode may be placed between two vertical sets of trays.

680,440. August 13, 1901; B. E. F. Rhodin, Sault Ste. Marie, Can.

Stationary horizontal pan contains layer of mercury and water. Electrolyzing chamber rotates on vertical axis within pan and consists of a series of radial anode compartments of vitrified earthenware, the sides of which extend down into the mercury. A central cup has radial ducts, which serve to distribute brine into each anode compartment.

680,441. August 13, 1901; B. E. F. Rhodin, Sault Ste. Marie, Can.

Anode for cell of patent No. 680,440, consisting of a supporting block of carbon having vertical threaded openings through which pass threaded carbon rods, construction permitting adjustment and renewal of rods.

692,531. February 4, 1902; E. A. Le Sueur, Rumford Falls, Me.

Outer iron cathode vessel, filled with water, receives electrolyzing chamber, a wooden cement-lined frame closed below by horizontal amalgamated wire gauze, the mercury acting as a bipolar electrode. A layer of gravel may rest on wire gauze. Level of brine in electrolyzing chamber somewhat lower than that of water outside, to give equal pressure on both sides of amalgamated gauze. A plurality of anodes, each consisting of platinum filaments radiating from a central stem, sealed in a glass tube. May connect cathode terminal directly to wire gauze.

693,678. February 18, 1902; G. M. Wilson, Sault Ste. Marie, Can.

Side passages carry amalgam from electrolyzing chamber into oxidizing chamber. Horizontal paddle wheel sweeps depleted mercury back over a dam and beneath vertical partition into electrolyzing chamber. Provides feed and overflow pipes in each chamber.

695,302. March 11, 1902; J. D. Gilmour, Glasgow, Scotland.

Electrolyzing chamber with carbon anodes and mercury cathode, placed within oxidizing chamber. Two series of short pipes extend from the lower portion of the outer chamber into and slightly above the bottom of the inner chamber. The outer vessel contains a layer of mercury and is filled with water. A pump continuously varies the pressure of the water and forces mercury up through one set of pipes into the electrolyzing chamber, while the amalgam flows out through the other set into the electrolyzing chamber. The caustic liquor overflows from the outer vessel at each pulsation of the pump.

699,401. May 6, 1902; C. J. Reed, Philadelphia, Pa.

In order to fully oxidize the sodium contained in a bipolar mercury electrode without oxidizing the mercury, and at the same time utilize the resulting current, employs a greater number of electrolyzing chambers than oxidizing chambers, and thereby causes the amalgam in each oxidizing chamber to contain sufficient sodium to transmit the entire current. The cathode of each electrolyzing cell consists of a series of amalgamated copper discs rotating on a horizontal axis and provided with curved grooves to distribute mercury, into which the lower edge of each disc dips, evenly over their faces. A carbon-plate anode depends between each pair of discs. In order to convey the depleted mercury from an oxidizing chamber to the next electrolyzing chamber without permitting the electric current to flow, uses a non-conducting transfer wheel with a series of pockets, which dip up and deliver the mercury in separate globules.

699,415. May 6, 1902; C. J. Reed, Philadelphia, Pa.

The electrolytic cell has in its bottom a plurality of parallel pockets filled with mercury. An amalgamated sheet-metal cathode is arranged over each pocket, being either a plate with means for vertically reciprocating it into and out of the pocket, or a disc carried by a horizontal revolvable shaft, with its lower edge depending into the mercury. The disc has curved grooves, which assist in taking up the mercury and distributing it over the surface of the disc. A carbon anode, which may be surrounded by a porous cup, depends between each pair of cathodes. The amalgam in the pockets is removed and replaced by mercury, as desired. The amalgam may be carried from the electrolytic cell into an oxidizing cell of similar construction, and the depleted mercury may then be delivered to a second set of electrolytic cells by a rotating transfer wheel having a series of pockets, which dip up and deliver the mercury in separate globules.

